PB-227 369

TREATMENT OF LAUNDROMAT WASTES

Donald B. Aulenbach, et al

Rensselaer Polytechnic Institute
Troy, New York

September 1971

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PB 227 369

EPA-R2-73-108
FEBRUARY 1973

Environmental Protection Technology Series

EP1.23/2:
73-108

Treatment of Laundromat Wastes

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D.C. 20460

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Sept. 1971

Treatment of Laundromat Wastes

Donald B. Aulenbach, Patrick C. Town, Martha Chilson

12120 DOD

Rensselaer Polytechnic Institute
Troy, New York 12181

Final
3/1/64 - 11/30/69

12. Sponsoring Organization Environmental Protection Agency

Environmental Protection Agency report number, EPA-R2-73-108, February 1973.

Laboratory and field studies were conducted to evaluate the laundromat waste treatment capabilities and the effluent recycling possibilities of two systems. The Winfair Water Reclamation System (WWRS) involves the addition of alum at a pH of 4, sand filtration, and passage through an ion exchange resin. The American Laundry Machinery Industries (ALMI) Diatomaceous Earth Filtration System employs chemical precipitation prior to filtration.

The WWRS resulted in a 61% BOD reduction, 71% COD reduction, 94% ABS reduction, and a buildup of total solids in the effluent. The system produced an effluent suitable for discharge into many streams. For effluent recycling, a functioning demineralizer would be required.

The ALMI System achieved a 70% BOD reduction, 84% COD reduction, 98% ABS reduction, 94% PO_4 reduction, and complete coliform removal. The increase in effluent alkalinity and hardness render very questionable the suitability of effluent reuse without softening and pH adjustment. The introduction of the system into existent laundromats would increase the cost of washes by about 10¢.

17a. Descriptors

17b. Identifiers

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Springfield VA 22151

19. Security Class (Report)

20. Security Class (Page)

21. No. of Pages 48

22. Price

Send To:

WATER RESOURCES SCIENTIFIC INFORMATION CENTER
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EPA-R2-73-108
February 1973

TREATMENT OF LAUNDROMAT WASTES

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OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price 95 cents domestic postpaid or 70 cents GPO Bookstore

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ABSTRACT

Laboratory and field studies were conducted to evaluate the capabilities of two commercially available laundromat waste treatment systems to treat laundromat wastes with the possibility of recycling the treated effluent. The Winfair Water Reclamation System (WWRS) involves the addition of alum to a pH of 4, sedimentation, sand filtration, carbon absorption, and passage through ion exchange resins. The American Laundry Machinery Industries (ALMI) system employs chemical precipitation prior to filtration through Diatomaceous Earth.

The WWRS achieved a 56% BOD reduction, 62% COD reduction, and 94% ABS reduction, but suffered from a buildup of total solids in the effluent. The system produced an effluent suitable for discharge into many streams. For effluent recycling, a functioning demineralizer would be required.

The ALMI system achieved a 63% BOD reduction, 69% COD reduction, 87% ABS reduction, 94% PO_4 reduction, and complete coliform removal. The increase in effluent alkalinity and hardness render very questionable the suitability of the effluent for reuse without softening and pH adjustment. The use of the system would cost about 10¢ per wash.

This report was submitted in fulfillment of Project Number 12120 DOD under the (partial) sponsorship of the Water Quality Office, Environmental Protection Agency.

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SECTION I

CONCLUSIONS

Part I

The Winfair Water Reclamation System was evaluated for its ability to treat a laundromat waste for possible reuse. Alum added to achieve a pH of 4-5 resulted in an effluent containing an average of 11 mg/l ABS. This is twice the level recommended for the detergent removal ion exchange resin. This will require replacing the resin twice as often as specified.

The BOD reduction was in the order of 61%, and the COD reduction 71%. This may be sufficient for discharge to many streams, and certainly satisfactory for discharge to a subsurface disposal system.

The demineralizer system was absolutely non-functional. This will result in a build-up of total solids if the effluent is reused. If the effluent is to be discharged to waste, the demineralizer system is not needed.

The system appears to operate satisfactorily without neutralization before sedimentation. The average ABS reduction was 94%, having an average residual of 2.3 mg/l.

With satisfactory operation of a demineralizer system, this effluent could be reused at least once in a laundromat. Consideration of the amount of make-up water to control the build-up of non-removed materials would have to be made. The system produces an effluent which should be suitable for discharge into many streams.

Part II

The American Laundry Machinery Industries (ALMI) Diatomaceous Earth Filtration System can be an effective system for laundromat waste treatment. Under optimum operating conditions the System can achieve better than 98% ABS reduction, 94% PO_4 reduction, 70% BOD reduction, and 84% COD reduction. Coliforms can also be effectively removed.

A 98% or better removal of the ABS can be achieved with the addition of 24 mg/l or greater of Roccal (a combination cationic detergent and germicide). No apparent relation was observed between calcium chloride addition and ABS removal, or between chemical addition and BOD or COD reduction. In most cases the COD exceeded the BOD.

The total dissolved solids in the effluent was directly related to the calcium chloride dose added. Thus to minimuze the increase in total dissolved solids, a minimum amount of calcium chloride should be used to effect treatment. The increase in total organic nitrogen due to treatment was not significant.

The turbidity of the effluent was directly related to the pH. At pH values above 8 with the addition of NaOH the transmittance was always greater than 95%. The transmittance dropped off sharply at pH values below 7.

There was a general slight reduction in the hardness due to the treatment; however, there are insufficient data to achieve a statistical significance to this conclusion. Several data suggest that an excess of $CaCl_2$ increases the hardness in the effluent.

Increased $CaCl_2$ dosage can result in an increased removal of phosphate. However, more significantly an increase in pH results in a marked increase in phosphate reduction with lower $CaCl_2$ dosages. Pre-treatment with alum followed by settling in the Winfair Water Reclamation System (WWRS) prior to treatment in the ALMI system resulted in a high phosphate removal at a low $CaCl_2$ dose.

The ALMI System meets most of the requirements for treatment of wastes from coin-operated laundromats. The introduction of this system into existent laundromats would increase the cost of washes by about 10¢.

SECTION II

RECOMMENDATIONS

Individual recommendations must be made on the basis of specific existing and potential uses of these treatment systems.

1. Treatment of laundromat wastes for discharge into the ground or to a surface water.

Either system could be used for this degree of treatment. The ALMI system is recommended due to ease of operation and greater reliability. Additional studies could be made into the reason for the failure of the demineralizer system in the WWRS.

2. Reuse of the treated effluent in the laundromat.

The WWRS was designed for reuse, whereas the ALMI system was not. Due to the malfunction of the demineralizer system of the Winfair Water Reclamation System (WWRS), the effluent from this system cannot be recommended for continuous reuse. Due to adverse conditions during operation of the American Laundry Machinery Industries (ALMI) system, no determination of the buildup in total solids could be made. In order to determine potential reuse, it is recommended that additional studies be made at a location where at least partial reuse of the effluent could be practiced.

3. Potential for phosphate removal.

In view of the use of alum in the WWRS and of calcium and potentially ferric chloride or alum in the ALMI system, both these systems have a potential for use in phosphate removal. It is recommended that additional studies be made of the use of these treatment systems for phosphate removal. (Note: This recommendation has already been carried out as reported in a paper entitled "Phosphate Removal From Laundry Waste Water" presented at the winter meeting of the New York Water Pollution Control Association in New York, January 26, 1972.)

4. Application to treatment of other types of liquid wastes.

Since both treatment systems have been shown to be reasonably effective in treating laundry wastes, they should also be effective in treating normal domestic sewage, especially for phosphate removal. The systems used in these studies could be used for small housing developments or shopping centers. The principles could be expanded to serve larger facilities. It is, therefore, recommended that studies be made to determine the applicability of these systems to treat domestic sewage, particularly for phosphate removal.

SECTION III

INTRODUCTION

There are many diverse types of wastes which produce problems today. One of these is the wastes from coin-operated laundromats, particularly those located in areas where sewer systems are not accessible. Numerous treatment systems have been devised for treating these wastes. Two such systems became available and formed the conception of this study. It is the purpose of this study to evaluate these two systems for the treatment of laundromat wastes.

The post-World War II era gave rise to three developments which complicated the laundry waste problem. First, was the mass production of automatic home laundry equipment. Second, the building boom in suburban areas placed much of this equipment in unsewered areas. Finally, the appearance of coin-operated laundromats in these new suburban centers meant that millions of gallons of detergent, germ, and soil-laden waste water was being discharged into streams, estuaries, ponds and groundwater supplies.

Since most of the early laundry detergents were not biodegradable, conventional septic tank systems were ineffective in treating these wastes. With the advent of biodegradable laundry detergents, some of the problems were ameliorated, but only if the coin-operated laundromats were located in areas where there was a sufficient quantity of suitable land for the construction of leaching fields. This was seldom the case since most of these installations were in densely populated new suburbs where land was at a premium. Therefore, waste treatment facilities for coin-operated laundromats in unsewered areas had to fulfill the following requirements:

1) provide an effluent acceptable to health regulations
2) handle peak loads as well as normal demands
3) require a minimum of service and operational maintenance skills and time
4) be able to be easily dismantled, transported and reassembled at a new site
5) occupy a minimum of space
6) be economically feasible in terms of cost per load of wash, and
7) whenever possible, recycle the water for further use.

The first part of this report evaluates the Winfair Wastewater Reclamation System (WWRS) which claims to fulfill all of the above requirements.

This second part of the report describes the operation of the American Laundry Machinery Industries (ALMI) wastewater treatment system, which claims to fulfill all but the recycle requirement of laundromat waste treatment system in unsewered areas, and evaluates the actual function of that system.

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SECTION IV

BASIC LAUNDRY WASTE TREATMENT SYSTEMS

Wastes from both individual home laundries and multiple-unit coin-operated laundromats can present problems where they cannot be discharged into sewerage systems provided with adequate treatment facilities. The spread of population into unsewered areas is followed by the establishment of coin-operated laundromats in these unsewered areas. An indication of the magnitude of the problem may be given by the estimate that there are over 120 laundromats in Suffolk County, Long Island, New York, alone[4]. A summary of the amounts of wastes produced is shown in Fig. 1 and representative quality parameters are shown in Fig. 2. Nearly all of these ultimately discharge their effluent into the ground. The switch to the use of synthetic detergents (syndets) has also contributed considerably to the problem. The conversion to linear alkyl benzene sulfonates (LAS) (Fig. 3) has reduced this problem where aerobic biological treatment is provided. However, under anaerobic conditions, such as in septic tanks and saturated soil, there is little breakdown of the LAS. In saturated soils, these syndets may travel considerable distances without being decomposed, thereby entering water supplies. In addition, studies on Long Island[3] have shown that the synthetic detergents seem to cause other pollutional material, specifically coliforms, to be carried greater distances than conventional soaps do. This is in partial disagreement with work done by Robeck, et al.[7] who showed that increased concentrations of ABS had no effect upon the travel distance of coliforms in water-saturated, sandy soils under laboratory conditions.

The problems created by laundromat wastes have led to many studies of methods for treatment, and to the creation of numerous waste treatment systems. A large volume of work was done at Manhattan College for the State of New York[6]. Work was done to determine the amount of alum needed to improve the quality of the waste (with no consideration of ABS removal), and further, the amount of powdered activated carbon needed to remove the ABS. An alum dose of 100 grains/gallon (1700 mg/l) and an activated carbon concentration 7 times the ABS concentration are recommended to remove substantially all anionic syndets. Close scrutiny of the data reveals that the optimum conditions for clarification of the waste without regard to ABS removal are 1530 mg/l of alum at pH 5.7, with the ranges being 850 - 2210 mg/l alum and pH 5.1 - 6.0. A dose of 1360 mg/l of alum and 340 mg/l powdered activated carbon at pH 6.0 produced an effluent containing 1.8 mg/l ABS. No studies were made to determine the removal of ABS by alum alone.

Flynn and Andres[4] recommended treatment with alum at pH 4.0 and powdered activated carbon to be effective in treating laundromat wastes. Rosenthal, et al.[8] conducted a more thorough study of laundromat waste treatment using alum and activated carbon. They found that 800 mg/l of alum alone at pH 4.5 removed 77 percent of the ABS. The acceptable pH range was 4.3 - 4.6. In the laboratory, 2000 mg/l powdered activated carbon (Nuchar) increased the ABS removal to 97 percent. In an actual

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FIGURE 1

LAUNDROMAT WASTE DISCHARGE*

Avg. Total Water Discharge/Laundromat	1.25×10^6 gal./yr.
Avg. Pounds Detergent/Laundromat (and other compounds)	4.2×10^3/yr.
Avg. Wastewater Flow/Machine	89-240 GPD
Maximum Avg. Flow/Machine	587 GPD
Minimum Design Basis for Treatment (12 hour day)	550 gal./machine

* 120 Launderettes - Suffolk Co., New York (1963)[4]

FIGURE 2

TYPICAL LAUNDERETTE WASTE[4]

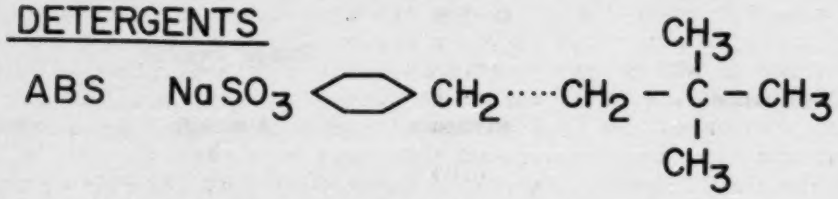
Substance	Range (mg/l)		
	Minimum	Average	Maximum
ABS	3.0	44.0	126.0
Suspended Solids	15.0	173.0	784.0
Dissolved Solids	104.0	812.0	2,064.0
COD	65.0	447.0	1,405.0
Alkalinity	61.0	182.0	398.0
Chlorides	52.0	57.0	185.0
Phosphates	1.4	148.0	430.0
pH	5.1	-	10.0
Nitrates	-	< 1.0	-
Free Ammonia	-	3.0	-
Sulfates	-	200.0	-

FIGURE 3

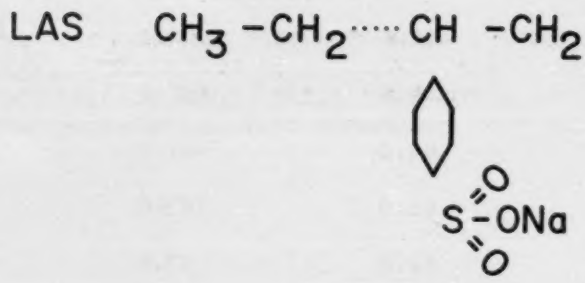
TYPICAL COMPOSITION OF DETERGENTS

DETERGENTS

ABS



LAS



COMPOSITION OF DETERGENTS	%
SURFACTIVES	10 - 30
AMIDE FOAM STABILIZERS	3 - 6
POLYPHOSPHATES	25 - 40
SILICATES	5 - 7
CARBOXY METHYL CELLULOSE (SOIL SUSPENSION)	0.5 - 1.0
SODIUM SULFATE	15 - 25
WATER	6 - 15

laundromat, alum plus 400 mg/l powdered activated carbon resulted in 83 percent removal of the ABS. The use of granular carbon in a series of three filters instead of powdered carbon increased the ABS removal to 99 percent in the laboratory and 93 percent in the plant. Further studies showed that alum coagulation at pH 11.4 with lime produced a clearer effluent which settled more rapidly and used less alum to achieve the same ABS reduction. Passing the alum-lime effluent through a 10 foot deep granular activated carbon pressure filter produced a 99.8 percent reduction in ABS in the laundromat waste treatment plant. Paulson[5] used granular activated carbon to remove syndets from filtered sewage plant effluents. He applied the effluent to 4 - 5 foot units in series at 10 gpm/ft^2, and regenerated the first unit when the ABS in the effluent reached 0.5 mg/l. Weber[10] determined that the ABS uptake by granular activated carbon increased with decreasing pH.

The basic types of laundry waste treatment systems have been studied by Flynn and Andres[4]. Their conclusion is that those employing alum at a pH of about 4.0 and powdered activated carbon produce the greatest reduction of ABS at the most reasonable cost in operation time, equipment and chemicals.

SECTION V

THE WINFAIR WATER RECLAMATION SYSTEM

A proprietory treatment plant utilizing the basic treatment principles of Flynn and Andres, that of employing alum at a pH of about 4.0 and powdered activated carbon[4], is manufactured by the Winfair Corporation, Green Lake, Wisconsin (now a subsidiary of the Oshkosh Filter Company, Oshkosh, Wisconsin). A complete Winfair Water Reclamation System was installed at the Coin-Op Laundry at Burnt Hills, New York. This is a small community north of Schenectady, where individual wells and waste treatment systems are the only means available to obtain water and dispose of liquid wastes, respectively. The ground water table in the immediate area surrounding the laundromat is near the surface, and is used as a water supply by some neighbors. Water about 70 feet below the surface is highly sulfurous and has a total dissolved solids content of around 700 mg/l. Permission could not be granted to dispose of the untreated laundromat waste in a septic tank system. The problems of water supply and disposal were both overcome by the installation of this complete water reclamation system.

In this system (Fig. 4) the washer effluents are first screened and then stored in a holding tank. From here a 15 gpm pump conveys the waste through the alum coagulation system. Alum is added to pH 4.2 - 4.5 and then the waste enters a 45 gallon upflow tank for floc formation (3 min. contact time). The effluent from this tank is treated with lye so that the pH after settling is 7.0 (pH slightly higher than 7.0 at the test point). The waste now travels through 3/4 inch copper tubing to the mid-depth of a large settling tank. The sludge is disposed of periodically and the clear supernatant is pumped through 1 of 5 pressure sand filters in parallel (3 gpm through each). The sand filter effluent passes up through a bed containing Duolite (Diamond Alkali Company, Redwood City, California) anion exchange resin A 102 D for detergent removal. After removal of the detergent, the waste passes up through a bed of granular activated carbon for taste, odor, and color removal. From there, 1/3 of the flow passes through a cation and an anion exchange resin for complete deionization. After recombination, the waste is chlorinated and the pH neutralized before it enters the clean water tank prior to reuse.

It appears that such a system should provide a satisfactory water for reuse in a laundromat. It is claimed that the cost of the additional treatment is offset by the saving of fresh water and reheating of the water, since it is normally still warm after passing through this treatment system. However, some difficulty was encountered after the system had been operating for several months. The detergent removal resin became saturated, and no longer functioned in its capacity to remove detergents. This resin cannot be regenerated by ordinary means and must be returned to the manufacturer for regeneration. Also, the two deionizer resins were entirely ineffective, causing the total solids in the

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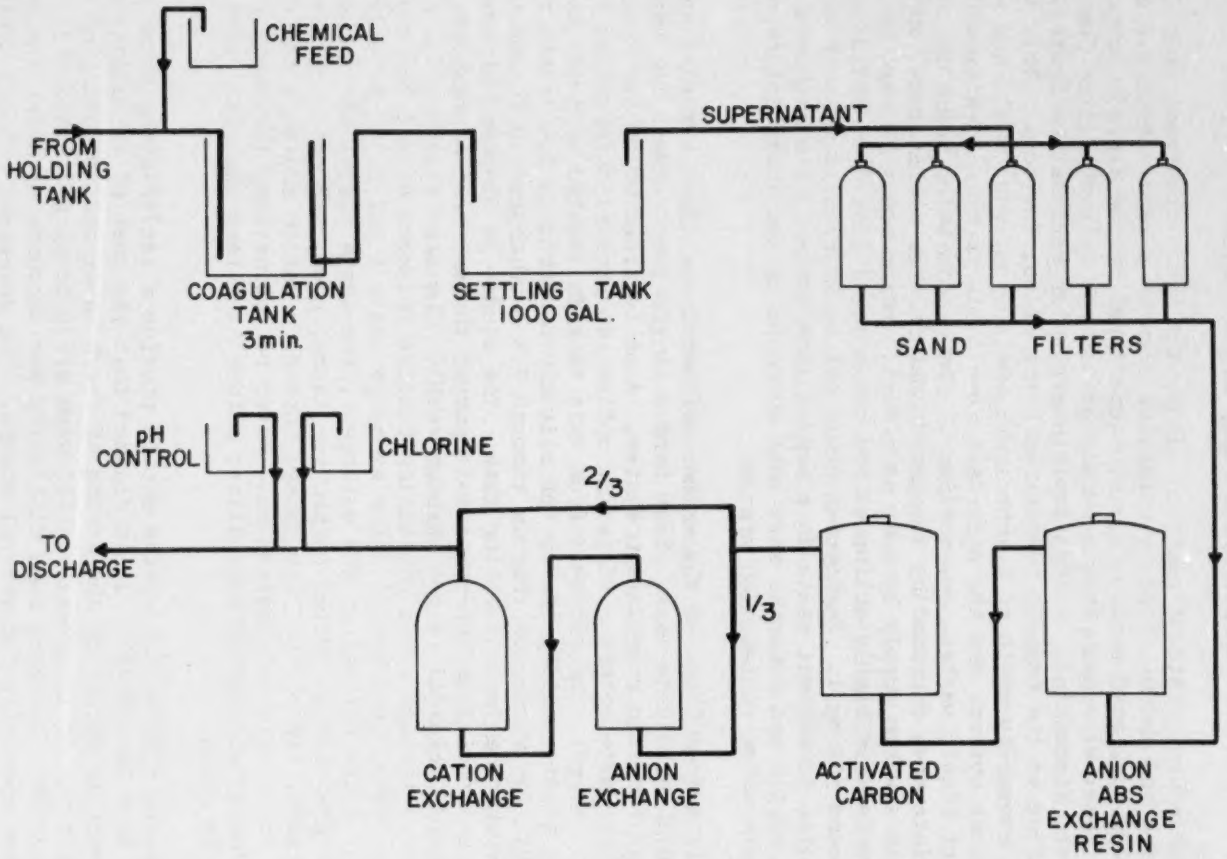

FIGURE 4-WINFAIR WATER RECLAMATION SYSTEM

recirculating water to increase constantly. These resins are normally regenerated weekly by conventional acid and alkali techniques. Efforts to rejuvenate them proved fruitless, and the total solids continued to increase.

The reason for the failure of the detergent removal resin was quite apparent. This resin was designed to function on the basis of an effluent from the alum coagulation system containing 5 mg/l of ABS or less. By test, the alum treatment effluent contained approximately 15 mg/l ABS. Thus, the resin became saturated in 1/3 the expected time. Replacement of this resin produced an effluent containing only 2 mg/l ABS after complete treatment. Further, the anion exchange resin in the deionizer would attempt to remove a portion of the residual detergent not removed by the other portions of the system. During the period when the detergent removal resin was saturated, a high detergent concentration reached the anion demineralizer where it was exchanged into the resin. Since the detergent cannot be removed from the resin by conventional means, this resin became saturated with the detergent and no longer functioned as an anion remover. No similar analogy can be made for the reason the cation exchange resin failed.

The major portion of the problem appeared to be the failure to achieve the expected ABS removal in the alum coagulation system. Whereas it was expected that this system should produce an effluent containing 5 mg/l of ABS or less, the actual effluent contained around 15 mg/l ABS, or a removal in the order of 50 percent. Since the work done at Manhattan College[6] did not include an evaluation of the removal of ABS by alum alone, and the work done by Rosenthal et al.[8] showed 77 percent removal of ABS by alum alone at pH 4.5, it was felt that further studies to determine the removal of detergent by alum coagulation alone were needed to evaluate the problem.

SECTION VI

LABORATORY STUDIES OF DETERGENT REMOVAL

Three series of experiments were performed to study the removal of detergents by the use of various concentrations of alum at various pH values. All mixing and coagulation were done using a typical 6-place multiple laboratory stirrer. Inasmuch as possible, an attempt was made to have the laboratory procedures reproduce the treatment provided by the Winfair Water Reclamation System. After adding alum, the samples were mixed at 50 rpm for 3 minutes. Then the pH was adjusted to the appropriate value, and coagulation was produced by stirring at 30 rpm for 10 minutes, after which the samples were allowed to settle for 30 minutes. Determinations were made for ABS to determine the detergent removal, and for chemical oxygen demand and turbidity to determine the quality improvement. The sludge volume after settling was also determined in order to provide some additional information on the amount of sludge storage capacity needed. ABS was determined by the methylene blue extraction technique, using 2 ml of sample. This volume of sample did not tend to produce emulsions during the extraction. All other analyses were made according to Standard Methods[9].

The waste samples were secured from the holding tank containing the mixed laundromat wastes. The only pre-treatment it received was screening to remove lint and other large particles. The temperature of the waste at the time of sampling was 40°C.

In the first test, sufficient alum was added to a portion of the waste sample to lower the pH to 4.5. This same amount of alum was then added to four other samples; a control containing no alum was given the same physical treatment. After mixing for 3 minutes, the pH of the samples containing alum was adjusted with acid or sodium carbonate as needed to values of 3.5, 4.5, 5.5, 6.5, and 7.5. No pH adjustment was made in the control. The results are summarized in Table 1, and the reductions in ABS, COD, and turbidity are shown in Fig. 5.

The best reductions in ABS and COD occurred at pH 4.5, whereas the best turbidity reduction occurred at pH 7.5. Actually the turbidity reduction was good throughout the entire pH range. The lowest sludge volume occurred at pH 3.5, although the amount of sludge produced at pH 4.5 was still quite low. The high total solids content of the waste reflects the failure of the deionizer in the treatment system. Also to be noted is that the alum treatment resulted in an increase in the total solids content of about 1,000 mg/l. The results from the control containing no added alum showed no ABS removal, and a slight increase in turbidity. The reduction in the COD of the control is likely due to sedimentation of larger particles. There was some sediment on the bottom of this container, but it was insufficient to measure on the percent scale. It is apparent that all the ABS reduction in the test samples was due to the added alum, and not due to plain sedimentation.

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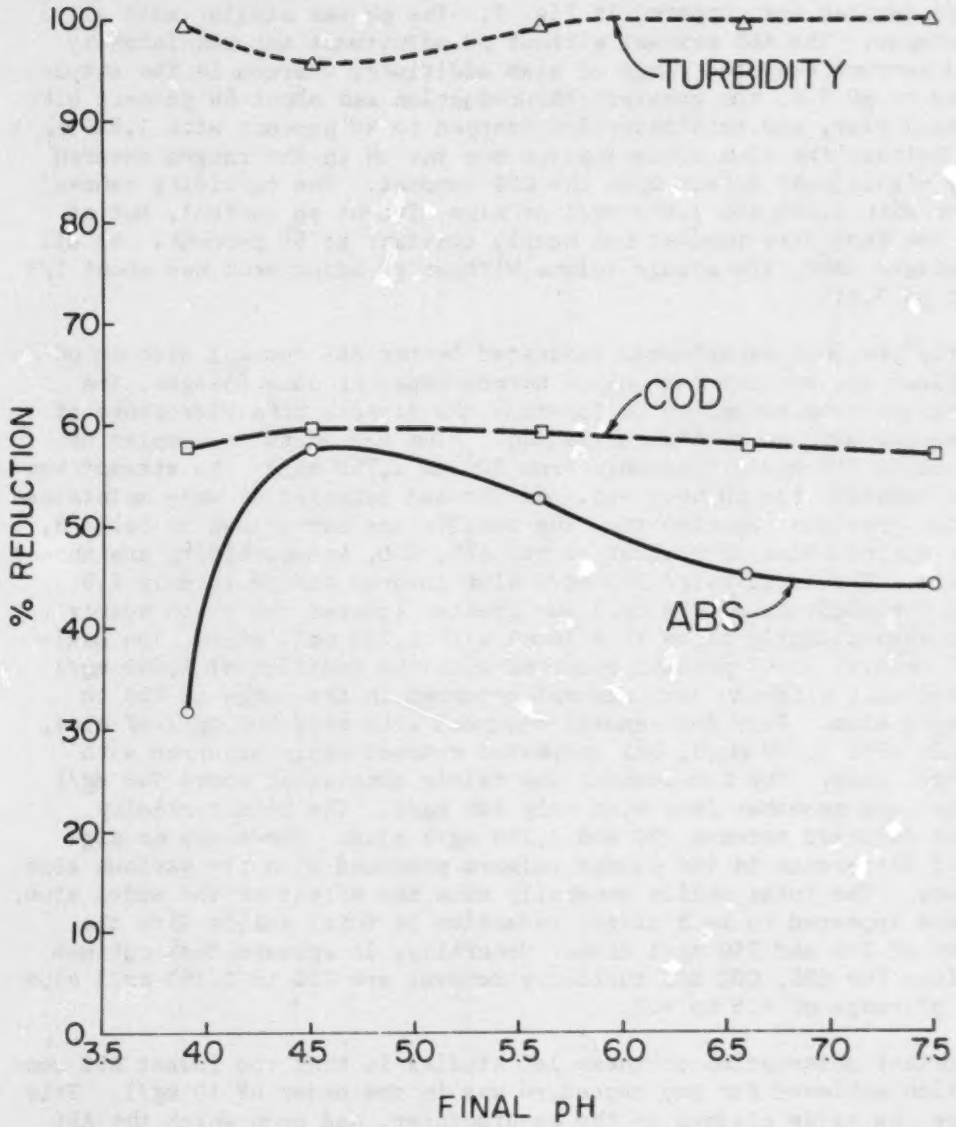
TABLE 1

EFFECT OF pH ON ALUM TREATMENT OF LAUNDROMAT WASTES

Sample	Waste	1	2	3	4	5	6
Alum Conc. mg/l	-	1500	1500	1500	1500	1500	0
pH	7.25	4.5	4.6	4.6	4.6	4.6	7.25
$H_2 SO_4$ Conc. mg/l	-	0.13	0	0	0	0	0
$Na_2 CO_3$ Conc. mg/l	-	0	0	455	740	1150	0
pH Before Settling	-	3.5	4.5	5.5	6.5	7.5	-
Final pH	-	3.9	4.5	5.6	6.6	7.5	7.3
ABS, mg/l	32.1	22	13.6	15.2	17.6	17.9	32.9
COD, mg/l	699	296	285	285	293	300	551
Turbidity, mg/l	125	1	5.5	1	0.8	0.5	140
Sludge Volume, %	-	3.7	8	40	24	28	0
Temperature, °C	22	-	-	-	-	-	-
Total Solids, mg/l	9,076	13,364	10,176	10,046	10,116	10,376	9,392

FIGURE 5

EFFICIENCY OF ALUM TREATMENT OF LAUNDROMAT WASTES AT VARIOUS pH VALUES



In an attempt to determine if satisfactory results could be obtained at any lower alum dosages, a second experiment was run adding 1,000, 1,250 and 1,500 mg/l alum. Further, in order to evaluate the recommended operation of the Winfair treatment system in which the alum treated mixture is neutralized to pH 7.0 before sedimentation, duplicate samples were run: 1 with no pH adjustment, and the other adjusted to pH 7.0 with sodium carbonate after 3 minutes mixing at 50 rpm and before 10 minute coagulation at 30 rpm. The results are summarized in Table 2, and the reduction in ABS, COD, and turbidity for the unneutralized and the neutralized samples are compared in Fig. 6. The pH was similar with all 3 alum dosages. The ABS removal without pH adjustment was consistently near 60 percent over the range of alum additions, whereas in the samples adjusted to pH 7.0, the greatest ABS reduction was about 50 percent with 1,000 mg/l alum, and this reduction dropped to 40 percent with 1,500 mg/l alum. Neither the alum concentration nor the pH in the ranges covered had any significant effect upon the COD removal. The turbidity removal was poor with 1,250 and 1,500 mg/l of alum without pH control, but at pH 7.0 the turbidity removal was nearly constant at 90 percent. At all alum dosages used, the sludge volume without pH adjustment was about 1/3 that at pH 7.0.

Since the previous experiments indicated better ABS removal with no pH neutralization, but covered only a narrow range of alum dosages, the next logical step seemed to be to study the effects of a wide range of alum dosages with no pH neutralization. Alum was added to samples of the waste in 250 mg/l increments from 500 to 1,750 mg/l. No attempt was made to maintain the pH near 4.5. Mixing and coagulation were maintained as in the previous experiments. The results are summarized in Table 3, and the efficiencies of removal of the ABS, COD, and turbidity are shown in Fig. 7. The addition of 500 mg/l alum lowered the pH to only 5.5 whereas the addition of 750 mg/l and greater lowered the pH to nearly 4.5 and even slightly below this level with 1,750 mg/l alum. The maximum ABS removal of 67 percent occurred with the addition of 1,000 mg/l alum, and only slightly less removal occurred in the range of 750 to 1,250 mg/l alum. Poor ABS removal occurred with only 500 mg/l of alum, and again with 1,500 mg/l, but increased removal again occurred with 1,750 mg/l alum. The COD removal was fairly consistent above 750 mg/l alum, but was somewhat less with only 500 mg/l. The best turbidity removals occurred between 750 and 1,250 mg/l alum. There was no significant difference in the sludge volumes produced with the various alum additions. The total solids generally show the effect of the added alum, but there appeared to be a slight reduction in total solids with the addition of 500 and 750 mg/l alum. Generally, it appears that optimum conditions for ABS, COD and turbidity removal are 750 to 1,250 mg/l alum in the pH range of 4.5 to 4.8.

An important observation of these lab studies is that the lowest ABS concentration achieved for any procedure was in the order of 10 mg/l. This is twice the value claimed by the manufacturer, and upon which the ABS removal resin is based. This means simply that the resin will be saturated in half the predicted time, or to put it another way, the cost for the ABS removal by the resin will be twice that predicted by the manufacturer.

TABLE 2

EFFECT OF VARIOUS CONCENTRATIONS OF ALUM AT
DIFFERENT pH'S FOR TREATMENT OF LAUNDROMAT WASTES

Sample	Raw Waste	1	2	3	4	5	6
Alum Conc. mg/l	-	1000	1000	1250	1250	1500	1500
$Na_2 CO_3$ Conc. mg/l	-	0	560	0	780	0	925
pH Before Settling	7.1	4.7	7.0	4.6	7.0	4.6	7.0
Final pH	-	4.6	6.9	4.6	7.1	4.5	7.0
ABS, mg/l	38.7	16.8	19.6	15.6	21.6	15.9	23.5
COD, mg/l	625	382	400	382	385	385	389
Turbidity, mg/l	128	15	3.9	52	4.6	76	5.4
Sludge Volume, %	-	9.5	22.2	8.7	28.5	8.2	26
Temperature, °C	20	-	-	-	-	-	-

FIGURE 6

EFFICIENCY OF VARIOUS ALUM DOSAGES FOR TREATMENT OF LAUNDROMAT WASTES AT SEVERAL pH VALVES

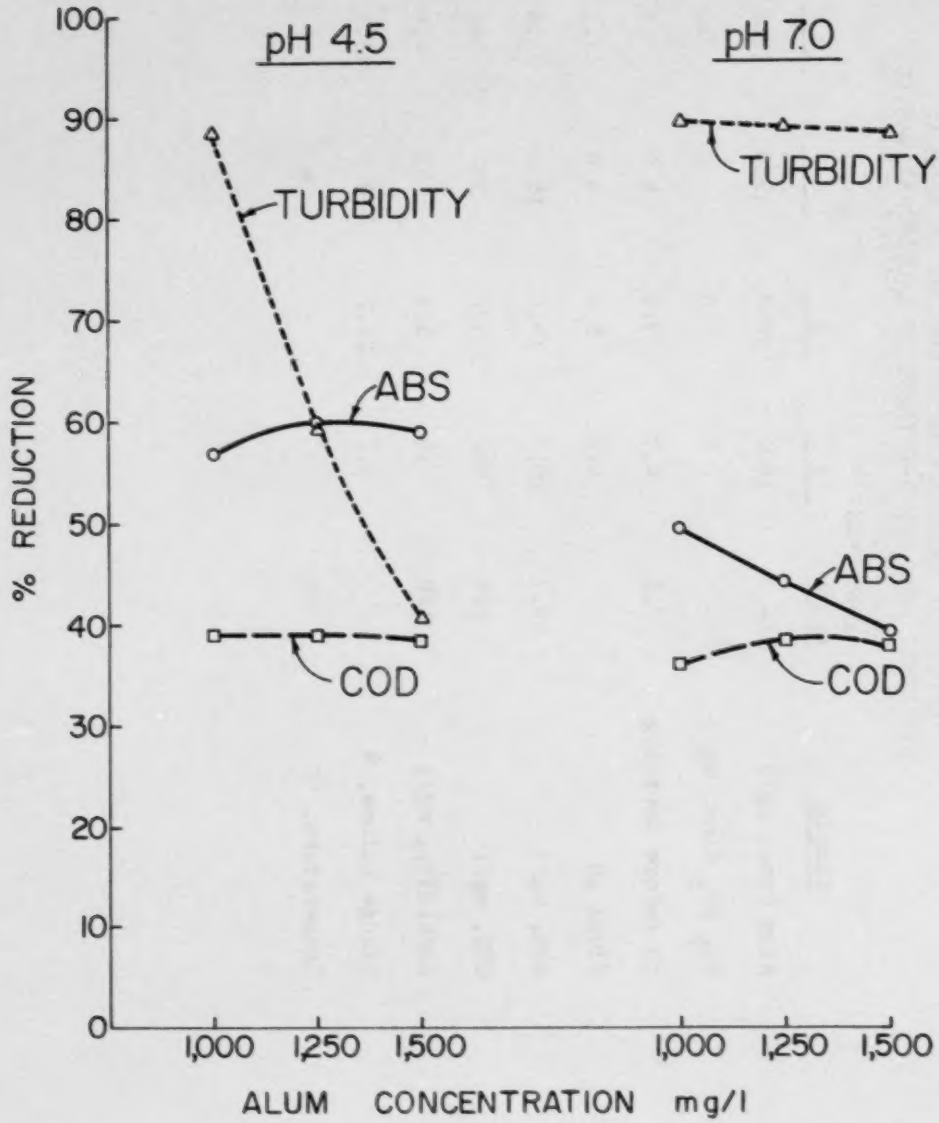


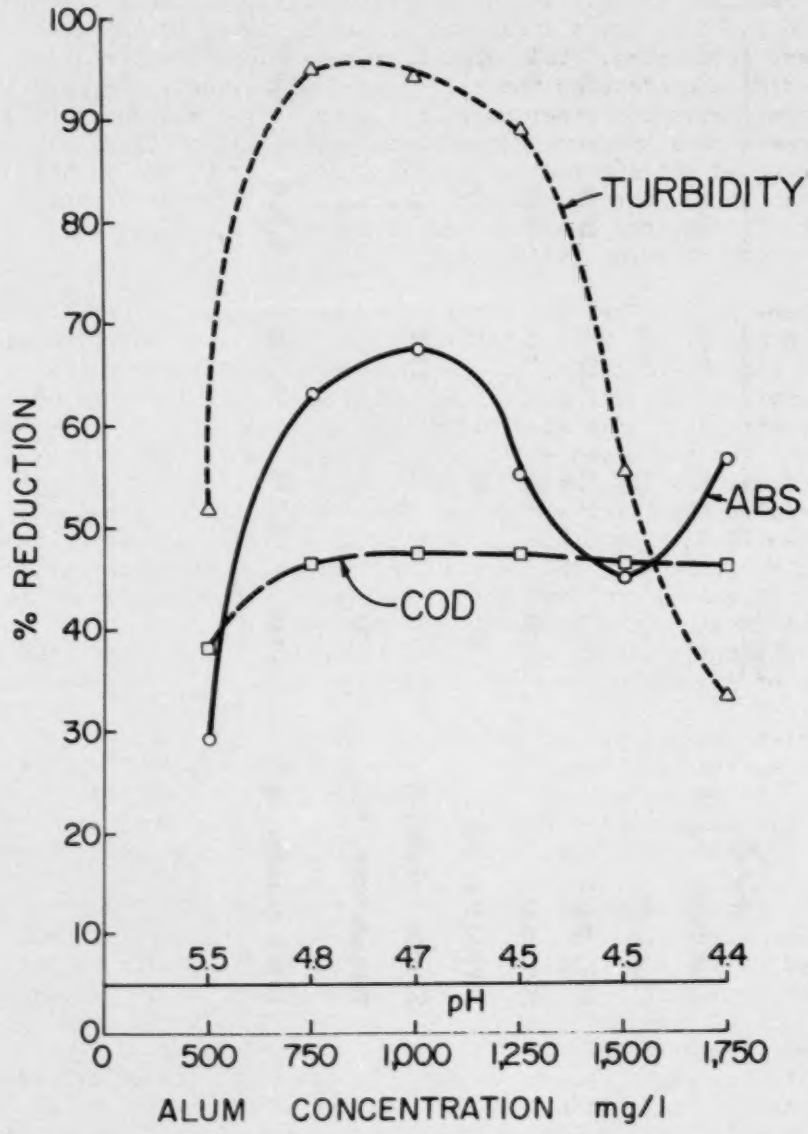
TABLE 3

EFFECT OF A WIDE RANGE OF ALUM CONCENTRATIONS
FOR TREATMENT OF LAUNDROMAT WASTES

Sample	Raw Waste	1	2	3	4	5	6
Alum Conc. mg/l	-	500	750	1000	1250	1500	1750
Final pH	7.2	5.5	4.8	4.7	4.5	4.5	4.4
ABS, mg/l	33.2	23.5	12.3	10.8	14.9	18.3	14.4
COD, mg/l	585	358	314	307	307	314	314
Turbidity, mg/l	135	65	7	8	15	60	90
Sludge Volume, %	-	9	13.2	12	10	10	7.5
Temperature, °C	21	-	-	-	-	-	-
Total Solids, mg/l	9,334	9,118	9,132	9,316	9,478	9,670	9,862

FIGURE 7

EFFICIENCY OF VARIOUS ALUM DOSAGES FOR TREATMENT OF LAUNDROMAT WASTES



SECTION VII

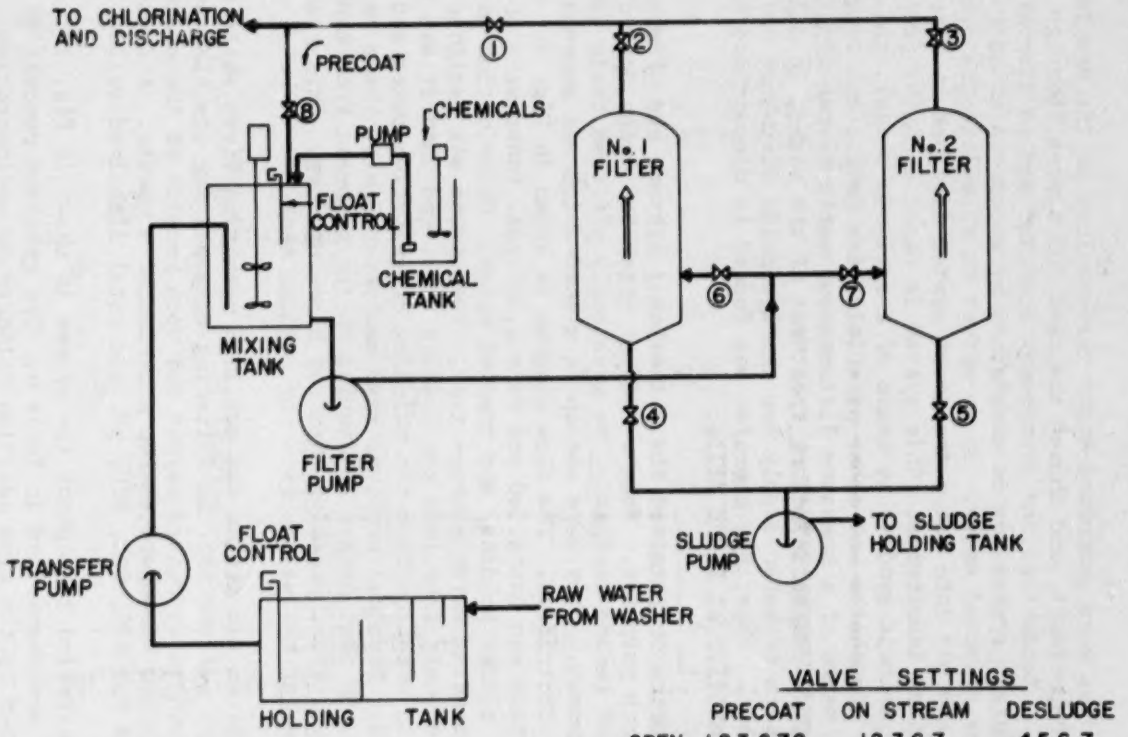
TREATMENT SYSTEM OPERATION

The above studies were performed under the auspices of the New York State Health Department, and showed the need for a more thorough study of the system. Meanwhile, the laundromat operator had to discontinue use of the Winfair system due to complaints by customers of odors and foaming in the recycled water. In an effort to alleviate the problem, he purchased and put into use a treatment system designed by American Laundry Machinery Industries. This system is based upon the precipitation of the anionic syndets by means of a cationic syndet, the precipitation of phosphates and other materials with $CaCl_2$, and separating the solids by means of a pressure diatomaceous earth filter (Fig. 8). Whereas this provided satisfactory treatment of the waste, it did not solve the problem of water supply nor the hydraulic discharge of the treated effluent. Thus, the operator was forced to discontinue his laundromat operation at Burnt Hills.

However, the operator retained the 2 treatment systems and offered their use for research purposes. When a Federal Water Pollution Control Administration Grant became available, he graciously offfered their use at another laundromat. They were set up in a shed which was somewhat remodelled and electrified. The flow diagram is shown in Fig. 9. A 4,000 gal. holding tank was installed and four 1,000 gal. tanks were provided for settling, sludge holding, and treated water. Chlorination was applied in the treated water storage tank. The system was designed so that the waste would flow into the holding tank, and when it was full, the waste would overflow into the existing distribution boxes and tile drainage field. Physical problems were encountered with these last two appurtenances, in that trucks delivering to the adjacent food market would drive over them, crushing them and blocking them. This resulted in the overflow of raw wastes from our holding tank.

The Winfair system was set up and put into operation first while replacements were awaited for the filtering elements for the ALMI system which were found to be rusted beyond use upon receipt of the units. The Winfair system was operated for a period of 9 months. Analyses were performed for ABS, COD, BOD, pH, and total dissolved solids.

The ABS concentration throughout the system is shown in Fig. 10. The actual values are summarized in Table 4. The greatest removal of ABS was accomplished by the alum addition followed by sedimentation. This was in the order of 76% of the initial ABS, and resulted in an average ABS, after settling, of slightly over 11 mg/l. This is in the same order as the laboratory experiments. The sand filter removed a little more ABS, but the detergent removal resin lowered the ABS to an average of less than 3 mg/l. This resin actually removed in the order of 70% of the remaining ABS. The activated carbon and the demineralizer system removed little additional ABS. The average overall ABS removal was 94%.



VALVE SETTINGS

	PRECOAT	ON STREAM	DESLUDGE
OPEN	1,2,3,6,7,8	1,2,3,6,7	4,5,6,7
CLOSED	4,5	4,5,8	1,2,3,8

FIGURE 8

SCHEMATIC FLOW DIAGRAM-AMERICAN LAUNDRY MACHINERY INDUSTRY-DIATOMITE FILTRATION SYSTEM

FIGURE 9
LAUNDROMAT TREATMENT PLANT

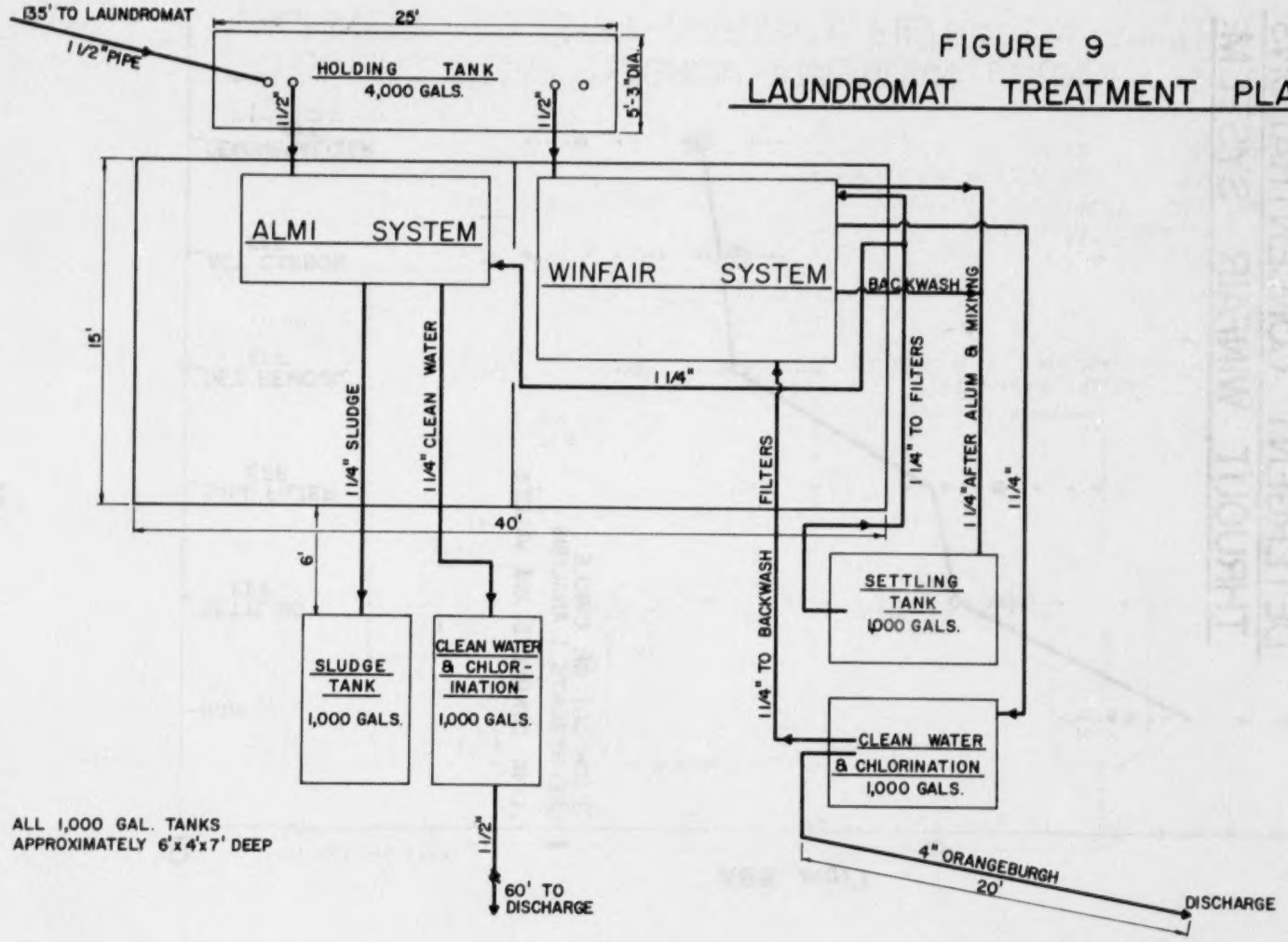


FIGURE 10

DETERGENT CONCENTRATIONS THRUOUT WINFAIR SYSTEM

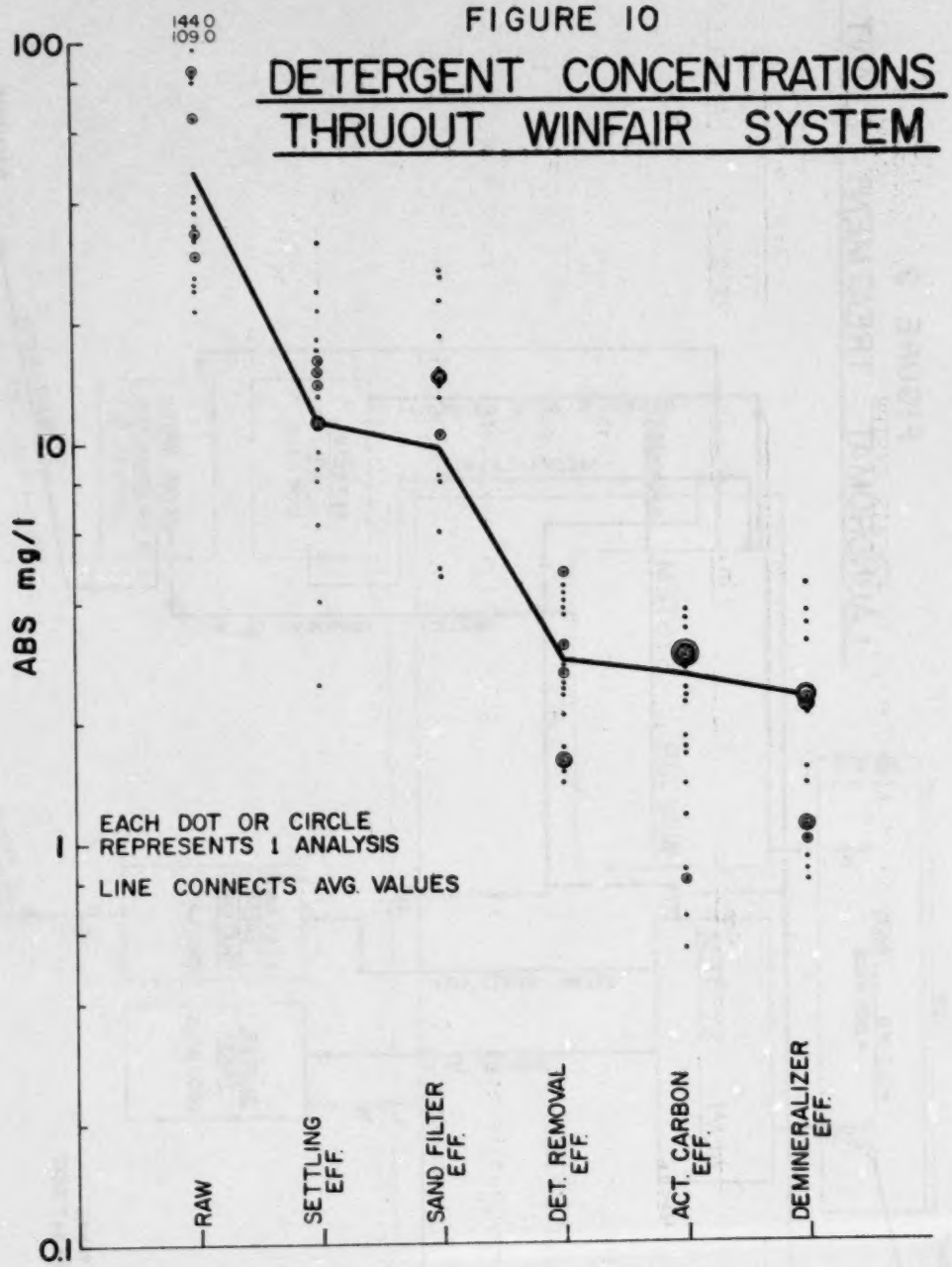


TABLE 4

SUMMARY OF ABS REMOVAL IN WINFAIR SYSTEM

Unit	Number of Samples	ABS, mg/l			Avg. Reduction	
		Max.	Min.	Avg.	% of Original	% of Remaining
Raw Waste	75	144.0	21.5	47.15	-	-
Settling Tank	67	31.5	2.5	11.25	76	76
Sand Filter	67	27.0	4.6	9.69	3	13
Detergent Removal	68	4.7	1.4	2.86	14	70
Activated Carbon	68	3.8	0.54	2.61	0.5	8
Demineralizer	74	4.4	0.08	2.31	0.6	11
Overall					94.1	

The BOD and COD results are summarized in Table 5. These parameters were determined to show the effectiveness of this system as a treatment system. If the effluent is to be recycled, these parameters must be followed in order to be alerted to an undesirable build-up. If the effluent is to be discharged, their concentrations must be known in order to determine if the effluent will be acceptable in the receiving body of water. The average BOD of the effluent was 52 mg/l and the average BOD reduction was in the order of 56%. The average COD of the effluent was 114 mg/l and the average COD reduction was 62%.

The pH (Table 6) of the raw waste was generally near neutral to slightly alkaline. On only two occasions was the pH below 6.8. These are considered due to the production of septic conditions in the holding tank. The pH adjustment in the flocculating tank was maintained between 3.9 and 5.1 with one value at 6.0. The pH increased more than one unit on an average as it passed through the settling tank. By the time it reached the end of the treatment system it reached an average value greater than 6.0.

The total dissolved solids pose a problem if the effluent is to be reused in a laundromat. The dissolved solids through each unit of the system are summarized in Table 7. The variation was greatest in the raw waste which had a minimum value of 625 mg/l and a maximum of 1,450 mg/l. The primary concern is that the overall system resulted in an increase of total dissolved solids, rather than the desired reduction. This is shown in Fig. 11. The greatest increase was due to the alum addition, and was in the order of 20 mg/l. The demineralizer, which was designed to reduce the dissolved solids, resulted in an average increase of 6 mg/l, or essentially no effective reduction.

The effluent from the system was chlorinated in the final holding tank before being discharged to a swampy area of a slow-running stream. This stream was little more than a drainage ditch which helped to drain the high water table of the surrounding area. All the houses in the area are provided with septic tank and tile field systems. The overflow from the holding tank (as described previously) also reached this swampy area. During warm weather an offensive odor arose from the stagnant stream, causing complaints by the neighbors. An injunction was brought against the laundromat operator to prevent the overflow of wastes from the holding tank. It was decided to install a float valve on the holding tank so the system would operate automatically when the holding tank was full. Even with the promise to have the float valve operative within a week's time, the judge closed the laundromat. This also resulted in the land owner's filling in the swamp and digging a channel to carry off the water, thereby eliminating the problem created by the stagnant water. Whereas the injunction closed the laundromat, there was no claim against the operation of the treatment system. Arrangements were made to transfer 2,000 gal./day of laundromat waste from another laundromat about 3 miles away. This allowed operation of the treatment system without moving the equipment. However, no further studies were performed using the Winfair system.

TABLE 5

SUMMARY OF OVERALL BOD AND COD REMOVAL
IN THE WINFAIR WATER RECLAMATION SYSTEM

Parameter	No. of Samples	Influent mg/l			Effluent mg/l			Average % Reduction
		Max.	Min.	Avg.	Max.	Min.	Avg.	
BOD	101	185	50	119.2	118	20.5	52.2	56.4
COD	70	438	136	293.4	244	38	113.8	62.1

TABLE 6

SUMMARY OF pH VALUES IN WINFAIR SYSTEM

Unit	No. of Samples	Max.	Min.	Avg.
Raw Waste	134	7.6	5.0	7.13
Flocculation Tank	136	6.0	3.9	4.45
Settling Tank	117	6.7	4.2	5.58
Sand Filter	117	6.7	4.5	5.76
Detergent Removal	117	7.0	5.0	5.95
Activated Carbon	117	6.9	5.2	5.99
Demineralizer	134	6.8	5.1	6.07

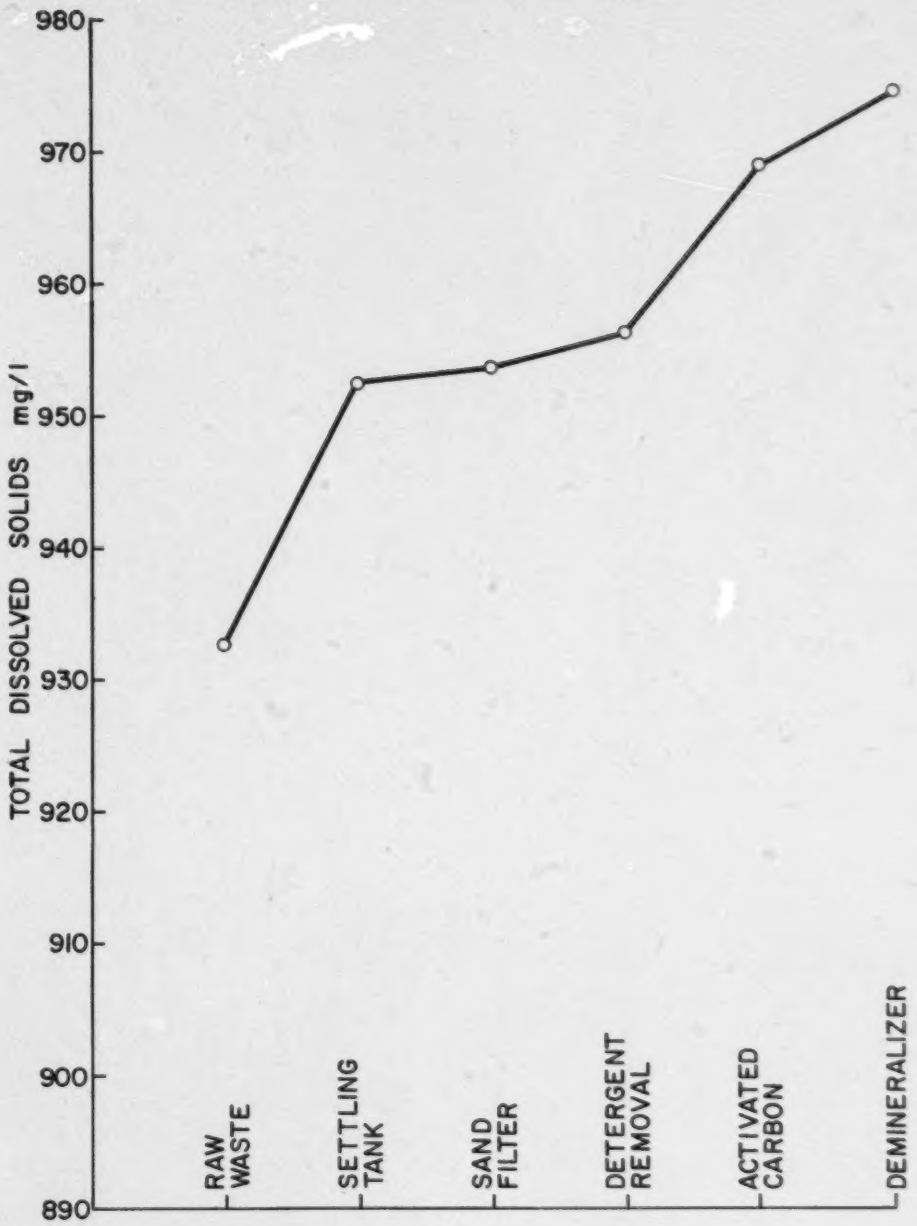
TABLE 7

SUMMARY OF TOTAL DISSOLVED SOLIDS IN WINFAIR SYSTEM

Unit	Number of Samples	Total Dissolved Solids, mg/l Max.	Min.	Avg.
Raw Waste	81	1,450	625	931
Settling Tank Eff.	79	1,425	750	952
Sand Filter Eff.	79	1,400	700	953
Detergent Removal Eff.	79	1,375	690	956
Activated Carbon Eff.	79	1,410	700	968
Demineralizer Eff.	81	1,325	750	974

FIGURE 11

SUMMARY OF TOTAL DISSOLVED SOLIDS IN WINFAIR SYSTEM - mg/l



SECTION VIII

DISCUSSION OF THE WINFAIR SYSTEM

The Winfair Water Reclamation System was operated for a period of nine months adjusting the pH of the raw waste with alum in the range of 4.0 to 5.0, but with no neutralization prior to sedimentation. The average ABS content after settling was 11 mg/l, which correlates well with the results of the lab studies. The value is double that which the manufacturer claims can be expected from this portion of the system. However, it is less than the 15 mg/l obtained by the original operator. It does confirm that the anion ABS exchange resin will be depleted in half the time predicted by the manufacturer. So long as consideration is made for this, it will not create a serious problem except for an increase in cost for the operation. The overall ABS reduction was 94%, resulting in a residual ABS of 2.3 mg/l. This is greater than the recommended drinking water standards but should be satisfactory for reuse in a laundromat.

The BOD and COD removals are intermediate between primary and secondary treatment. The residual may or may not be acceptable for discharge depending upon the receiving stream. This would also depend on the volume of the waste from each individual laundromat under consideration. Generally speaking, the average BOD of 52 and the average COD of 114 in the effluent are considered rather high for recycling of the effluent. Chlorination may reduce these slightly and also prevent septic conditions in the recycle holding tank.

pH was to have been an important key in this study. Since the initial pH adjustment was difficult to establish, it was expected that a wide range of pH values would be obtained allowing for an evaluation of the degree of treatment over a wide pH range. Instead, the lab assistants went to extreme pains to maintain the pH between 4.0 and 5.0 in order to obtain what the laboratory studies had shown to be the pH for the greatest purification. An attempt was made to correlate the pH vs treatment, but the results showed no conclusive trend. It is interesting to note that when the system was first set up and operated to get the bugs out, on one occasion the pH in the flocculation tank was 6.0, and the ABS in the effluent was recorded as 0.0. Since this was a break-in period both from the standpoint of operating the system and perfecting lab techniques, no great value can be placed on this single result.

One of the greatest disappointments was the operation of the demineralizer system for removal of the total dissolved solids. The increase in the total dissolved solids due to the addition of the alum of about 20 mg/l was less than that of up to 1,000 mg/l experienced in the lab studies. This indicates better control and separation in the system than in the lab. The increases in passing through the remaining units of the system are insignificant. However, when it comes to the demineralization, this is supposed to reduce the total solids, not result in an

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insignificant increase. When the system was started up, fresh resins were placed in the units. Some difficulty was found in balancing the valves so that approximately one-third of the flow passed through the demineralizers. After this was established samples were secured for the dissolved solids test which showed no reduction. It is possible that in establishing the flow, the resins became exhausted. Therefore, they were regenerated as per specifications, but with no change in results. Numerous efforts were made to regenerate the resin and they were completely replaced later in the study. The flow was regulated to all extremes including passing all the liquid through the resins. All of these efforts proved fruitless. It can only be concluded that the demineralizer system provided by the company was not capable of performing the job for which it was designed. This is the same conclusion reached with the initial evaluation of the failure of the system in its first location.

Although the possibility of reuse of the treated effluent was considered, it was not attempted in any of these studies. The water supply for the laundromat was adequate, and it was felt that the existing good quality water would be preferred to reused water. The only advantage that could have been gained by reuse would have been a saving in waste water that would have had to be discharged. The quality of the effluent is considered to be adequate for reuse in a laundromat, but certainly not for drinking. No consideration could be made of the number of reuse cycles that could have been made before the build-up of non-removed materials would reach an undesirable level.

It is also considered that this treatment would result in an effluent which could be discharged into a subsurface disposal system with a minimum of problems.

SECTION IX

THE ALMI FILTRATION SYSTEM

As early as 1944, the U.S. Army Corps of Engineers developed a diatomite filtration unit for use in supplying safe and potable water for field troops[1]. These units had to (a) be portable and (b) operate at a high rate of output. Since the nation was then involved in a global war, the economic factor was not of great import in evaluating the overall success of the system. In addition to the conventional health and aesthetic requirements, the system had to remove the cysts of Endamoeba histolytica and the cercaria of schistosomes. This was particularly crucial in both the South Pacific and the Mediterranean Theatres of war. At flow rates of 6 to 12 gpm psf, many cysts passed through conventional sand type filtration units. On the other hand, the diatomite filters affected virtually complete removal of cysts under the most severe tests.

These findings were again utilized as the post World War II boom of home laundries and public laundromats spread into unsewered areas, increasing the need for effective treatment units. The American Laundry Machinery Industries (ALMI) Diatomaceous Earth Filtration System was developed for such laundry waste treatment.

Structually, the ALMI wastewater treatment system (WWTS) used is a continual water filtration system consisting of a mixing tank, 2 chemical feed tanks, 2 pressure filter units operated in parallel, and the appropriate pumps, valves, and connecting piping. Additional appurtenances include a 4,000 gal. raw wastewater holding tank to provide flow equalization, a 1,000 gal. treated water tank which served as a chlorine contact tank, and a 1,000 gal. sludge holding tank which retained the filtered materials plus the spent diatomaceous earth (DE) until hauled away by a scavenger. Each filter unit contains 45 vertical mesh screen tubular elements (total of 90 elements) which serve as a septum for the diatomaceous earth (DE) precoat. Figure 12 shows an 8,000 GPD system. A schematic flow diagram is shown in Figure 13. The principal characteristics of this unit are listed in Table 8.

System operation consists of applying a precoat on the filter elements by recirculating a water suspension of DE from the mixing tank through the filters with return to the mixing tank. The precoat operation usually requires 3-6 min. using a 45 lb. change of diatomaceous earth. Following precoating, the waste purification cycle is intitiated by pumping wastewater from the holding tank to the mixing tank, through the filters and to the treated water tank. A purification cycle normally lasts 15 minutes during which 400 gallons of wastewater are processed at a flow rate of 25 GPM. Following each 15 minute filtration cycle, a timer switch shuts off the filter pumps and activates a mechanical shaker mechanism which "bumps" off the precoat from the filter elements. The precoat and filtration cycles are then repeated following completion of the bump phase. The periodic bump to remove and re-precoat the filter elements restores pressure drop loss which occurs as solids

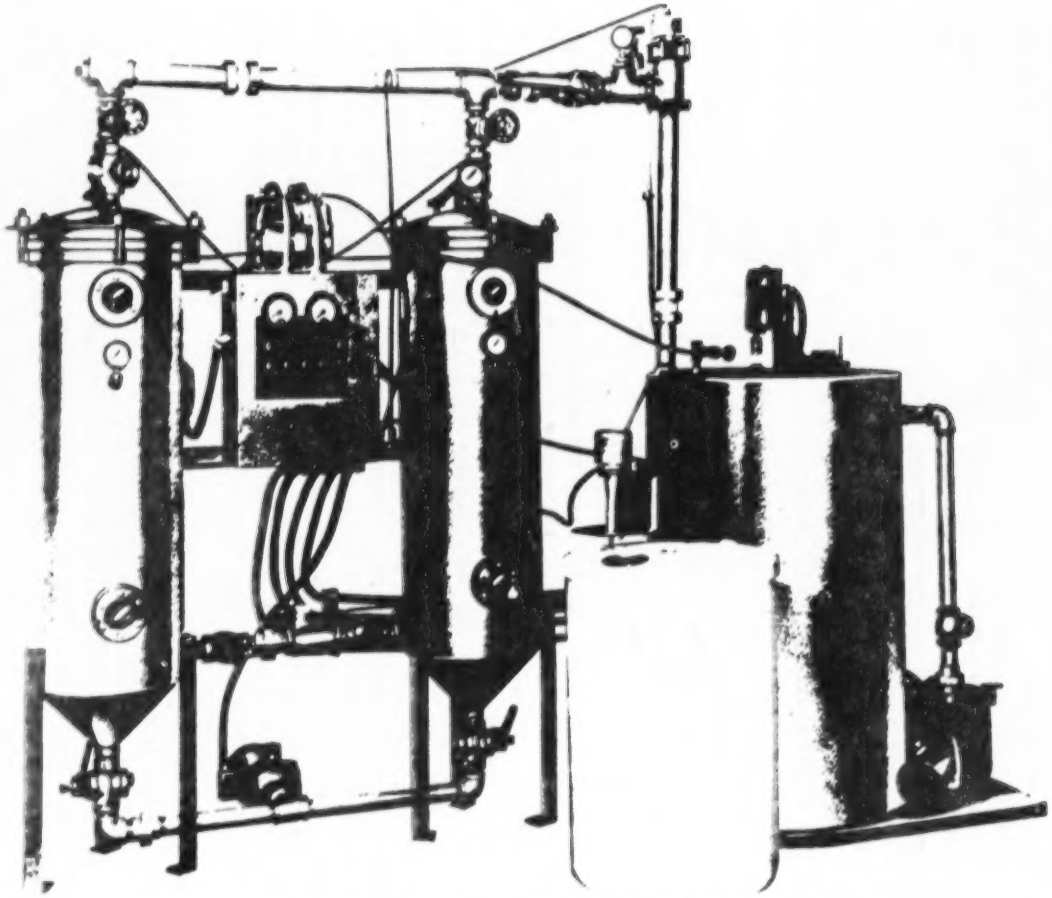
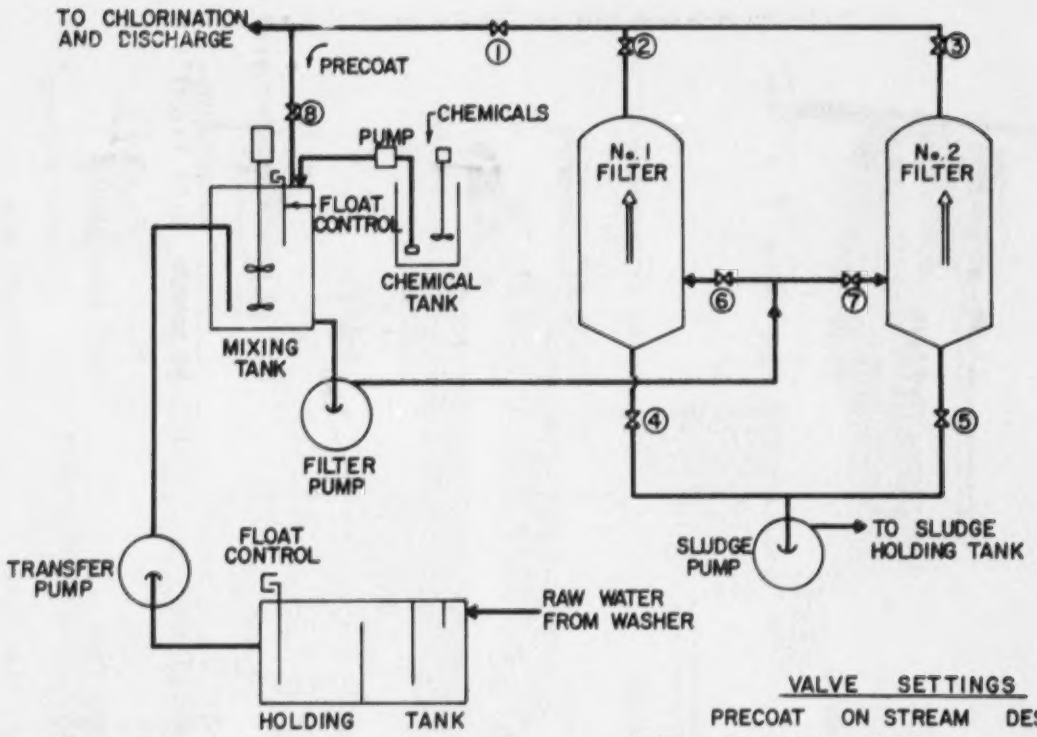


FIGURE 12. AMERICAN LAUNDRY MACHINERY INDUSTRIES WASTE WATER TREATMENT SYSTEM



VALVE SETTINGS

	PRECOAT	ON STREAM	DESLUDGE
OPEN	1,2,3,6,7,8	1,2,3,6,7	4,5,6,7
CLOSED	4,5	4,5,8	1,2,3,8

FIGURE 13

SCHEMATIC FLOW DIAGRAM-AMERICAN LAUNDRY MACHINERY INDUSTRY-DIATOMITE FILTRATION SYSTEM

TABLE 8

AMERICAN LAUNDRY MACHINERY INDUSTRIES
DIATOMACEOUS EARTH FILTRATION SYSTEM

Overall Size	
Base	5'-3" X 5'-5"
Height	7'-2"
No. Filter Elements	90
Size	25.5" long X 1" dia.
Mesh	60
Filter Element Area	0.564 ft^2/element
Total	50.76 ft^2
Normal Flow	
In	25-26 gpm
Out	14-15 gpm
Flow Loading	~ 0.5 gpm/ft^2 filter area
Diatomite Charge	45 pounds (0.89 lb./ft^2)
Normal Total Daily Flow	6300-8500 gals.
Chemical Feed Solution Rate	60-70 ml./min.

accumulate on the filter elements. Figure 14 illustrates the rate of pressure drop increase (and flow decrease) as a function of number of filtration cycles.[2] Usually, it is possible to achieve 10-15 filtration cycles with one DE charge, which allows processing of 4000-6000 gals. of wastewater.

The recommended chemical operation of the ALMI system consists of the addition of $CaCl_2$ and Roccal (commercial name for a quaternary ammonium compound which is in effect both a cationic detergent to remove residual anionic detergents and a germicide to kill bacteria) to the raw waste in the mixing tank. In addition, NaOH, alum and ferric chloride were added in tests to study the removal of phosphates. Finally, sodium hypochlorite (Clorox) was added to the effluent to reduce bacteria.

The entire chemical reactions of the ALMI Wastewater Treatment System take place in the mixing tank. They are designed to neutralize and/or precipitate phosphates, spent detergents, nitrates, organic matter and suspended particulates in the wastes. To the degree that the the chemical process is effective, these substances are then trapped upon the filter medium, theoretically leaving a clear, odorless and non-pathogenic effluent low in organic matter.

This entire phase of this study was conducted under less than ideal conditions. Just prior to commencing Part II of this project, an injunction was obtained against the laundromat operator, forcing him to shut down his operation. This was due to an overflow of wastes from the holding tank at the treatment plant. The system was designed so that when the holding tank was full, the waste would spill over into a septic tank and leaching system. However, delivery trucks had crushed the pipes leading to the septic tanks and tile fields, so that the waste overflowed at the holding tank. Fortunately, the injunction which closed the laundromat said nothing about the treatment plant, so arrangements were made with the operator of a laundromat about 3 miles away to truck 2,000 gal. per day from his septic tank to our holding tank. This waste was septic and not fresh as the local waste was. This probably made the waste more difficult to treat. It was assumed that if this system could treat this septic waste satisfactorily, it could do an even better job of normal fresh laundromat wastes.

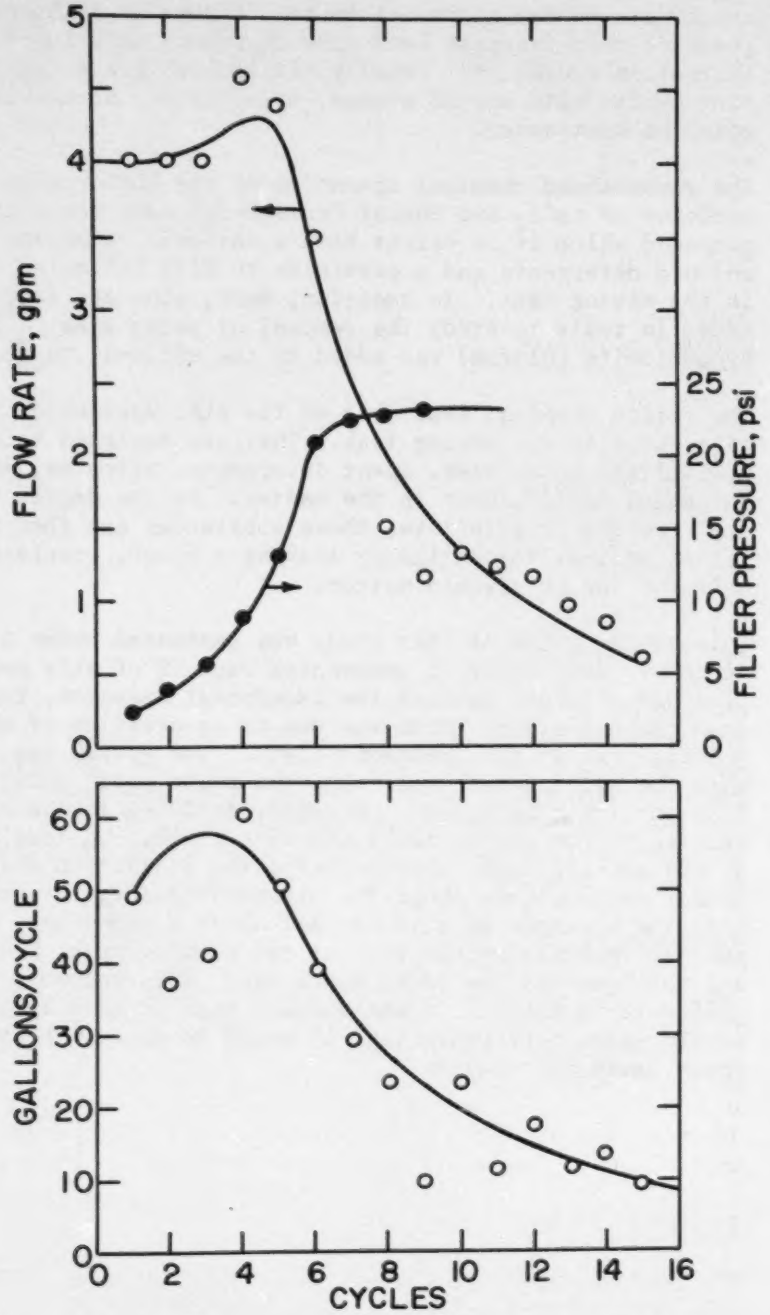


FIGURE 14 - ALMI SYSTEM PRESSURE DROP-FLOW CHANGES

SECTION X

LABORATORY ANALYSIS

Discussion of the information available from the data is expanded for each of the parameters measured, and then the most nearly optimum operating conditions are evaluated.

ABS Removal

With one exception, 97% or better ABS removal was achieved with Roccal dosages of 26 mg/l and greater as summarized in Table 9. With one exception, the ratio of $CaCl_2$ to Roccal ranged between 4.78 - 5.1 on these occasions. Poorer ABS removals occurred when the Roccal addition dropped below 26 mg/l and the $CaCl_2$: Roccal ratio was greater than 10. The summary of the removal of ABS is shown in Table 10. The concentration of ABS in the raw waste was fairly constant with a variation only from 16 to 26 mg/l and an avg. of 20 mg/l. The highest value in the effluent was 5.2 mg/l and on numerous occasions the ABS was removed completely. The avg. ABS in the effluent was 2.5 mg/l, representing an avg. reduction of 87%.

BOD Reduction

The values of the BOD reduction are summarized in Table 11. The highest BOD recorded in the influent was 371 mg/l, but the next highest value was 168 mg/l. The avg. BOD of the waste was 126 mg/l. The avg. BOD of the effluent was 47 mg/l. The avg. reduction was 63%; the max. was 82% and the minimum 7%. The 82% reduction was achieved using a 46 lb. charge of Pitcher Celatom and resulted in an actual reduction of BOD from 109 mg/l to 20 mg/l.

COD Reduction

Table 12 shows the summary of the COD reduction. The COD of the influent ranged from 200 to 455 mg/l with an avg. value of 340 mg/l. The values in the effluent ranged from 42 to 196 mg/l with an avg. of 104 mg/l. The greatest reduction of 84% occurred on two occasions and the poorest reduction was 31%. The avg. reduction in COD was 69%. The best COD reduction was achieved using Diatomite in a 44 lb. charge resulting in actual reductions of 258 & 285 mg/l to 42 & 45 mg/l, respectively.

Turbidity Reduction

The turbidity of the effluent varied appreciably with the pH as shown in Fig. 15. (Percent transmittance is plotted instead of actual turbidity; a high transmittance indicates a low turbidity.) It may be seen that the best turbidity removal occurs when the pH is adjusted to values greater than 8. Table 13 shows the variation of the effluent turbidity with various dosages of each of the diatomaceous earths used. The best

TABLE 9

SUMMARY OF ABS REDUCTION WITH VARIOUS $CaCl_2$ AND ROCCAL ADDITIONS

Date	Roccal Dosage (mg/l)	Ratio $CaCl_2$ To Roccal	Average Reduction %
8/27/69	110.0	4.8	100
8/6/69	105.0	4.8	No Data
8/27/69	88.5	4.6	97.77
8/7,8,11/69	84.0	4.8	100
9/17/69	64.0	4.9	97.76
8/21/69	63.2	11.5	99.04
8/19/69	63.0	4.8	91.59
8/12/69	56.0	4.8	100.00
8/26/69	55.6	4.8	99.31
8/26/69	48.5	5.1	98.10
9/17/69	45.0	4.9	97.78
8/19,21/69	32.0	4.8	98.25
8/13/69	29.2	4.8	99.37
9/20/69	26.2	9.9	97.93
9/22/69	24.0	6.75	38.33*
8/29/69	23.8 (NaOH Added)	24.0	97.96
9/20/69	20.2	9.7	88.45
11/18/69	20.0 (Alum + $FeCl_3$ Added)	No Data	No Data
8/28/69	19.8 (NaOH Added)	23.8	81.02
8/29/69	18.3 (NaOH Added)	23.8	80.48
9/3/69	15.4 (NaOH Added)	22.7	72.43
9/11/69	15.2	10.1	75.98
8/14,15/69	12.0	4.7	77.58
9/3,4/69	9.2 (NaOH Added on 9/3 Only - Results Not Typical)	23.7	46.34

* 1500 mg/l Alum Added, Settled in WWRS Before ALMI Treatment

TABLE 10

SUMMARY OF REMOVAL OF ALKYL BENZENE
SULFONATE IN THE A.L.M.I. SYSTEM

INFLUENT					EFFLUENT					REDUCTION				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	%	Date	%	%
8/26	25.7	8/8	15.7	20	9/3	15.3	8/2,7,8, 11,27	0	2.5	8/2,7, 8,11,27	100	9/3	18	87

TABLE 11

SUMMARY OF REDUCTION OF BIOCHEMICAL
OXYGEN DEMAND IN THE A.L.M.I. SYSTEM

INFLUENT					EFFLUENT					REDUCTION				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	%	Date	%	%
8/14	371	8/21	80	126	8/16	102	9/4	15	47	8/21	82	8/16	7.3	63

TABLE 12

SUMMARY OF REDUCTION OF CHEMICAL OXYGEN DEMAND IN THE A.L.M.I. SYSTEM

INFLUENT					EFFLUENT					REDUCTION				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	%	Date	%	%
8/19	455	8/8	200	340	8/6,19	196	8/26	42	104	8/26,29	84	8/19	31	69

FIGURE 15 - EFFLUENT TURBIDITY VS pH IN THE A.L.M.I SYSTEM

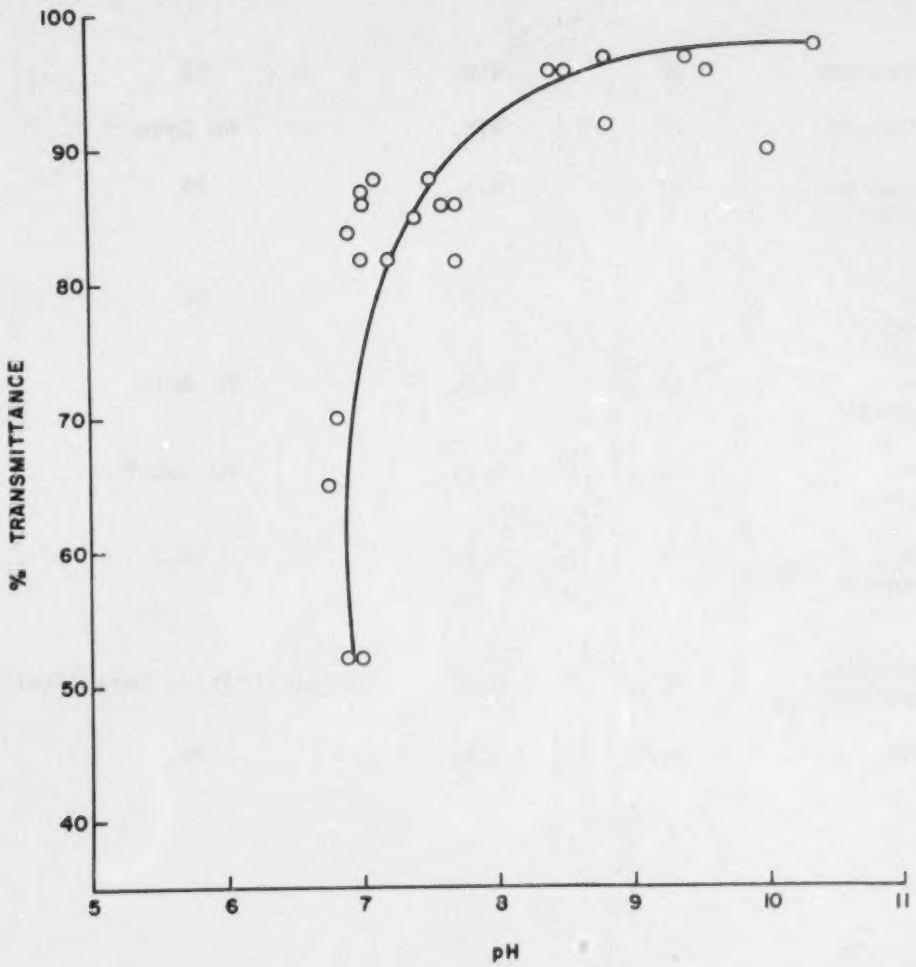


TABLE 13

EFFLUENT TURBIDITY VS. FILTER AID

Filter Aid	Dosage Lbs.	Average pH	Avg. % Transmittance
Diatomite	24	7.1	87
Diatomite	42	7.4	85
Diatomite	44	7.4	81
Pitcher Celatom	46	N.D.	61
Pitcher Celatom	43	N.D.	No Data
Pitcher Celatom (NaOH Added)	50	9.1	96
Diatomite (NaOH Added)	43	N.D.	91
Diatomite (NaOH Added)	37	N.D.	No Data
Diatomite (NaOH Added)	43	N.D.	No Data*
Diatomite (NaOH Added)	43	N.D.	59.5
Johns-Manville Hyflo-Supercel	44	N.D.	No Quantitative Data (Poor)
Celite 545	44.5	7.6	79.5

* Six (6) Minute Precoat Hereafter

reduction of turbidity was achieved using Pitcher Celatom at a 50 lb. charge resulting in an effluent which manifested 96% transmittance.

Organic Nitrogen

The small number of results for Kjeldahl nitrogen available are summarized in Table 14. Although the data are not statistically significant, on one occasion there was an increase in the organic nitrogen of 146% from the influent to the effluent; on the other two occasions there was a reduction.

Total Dissolved Solids Increase

In all cases, due to the chemicals added for the treatment, there was an increase in the total dissolved solids as shown in Table 15. The average increase was 61%. The greatest increase was 144% from 450 mg/l to 1,100 mg/l. The least increase, 3%, from 390 and 400 mg/l to 400 and 410 mg/l, respectively, occurred using Diatomite in a 44 lb. charge combined with 56 mg/l of $CaCl_2$ and 12 mg/l of active Roccal. That the increase in total dissolved solids is directly related to the $CaCl_2$ added is shown visually in Fig. 16.

Hardness

The scant hardness data do not lend themselves to statistical evaluation. It would be useful to correlate hardness in the effluent with $CaCl_2$ dosage, but this is not possible. A summary of the existing data is shown in Table 16. The hardness in the influent varied only between 172 and 248 with an average of 209 mg/l. On two occasions on the same day there was an extreme increase in hardness in the effluent to 620 and 668 mg/l. Including these two values the average hardness in the effluent was 284 mg/l showing an average increase of 36%. Excluding these two abnormal values there was an average reduction of 20% to 166 mg/l.

Phosphate Removal

It is well known that phosphate removal is directly related to the pH of the solution. This is shown clearly in Fig. 17. Below pH 7.5 the phosphate removal was in the order of 25%, whereas above pH 8.5 it was above 90%. To show any effect of $CaCl_2$ dose on phosphate removal, Fig. 18 was constructed. It may be seen that increased $CaCl_2$ dosage does result in a greater removal of phosphate, but this removal approaches only 50% with $CaCl_2$ dosages up to 700 mg/l. On the other hand, $CaCl_2$ dosages in the range of 400 to 600 mg/l removed over 90% of the phosphate when NaOH was added. When alum was added and the waste settled in the Winfiar system prior to treatment in the A.L.M.I. system, an 85% reduction of phosphate was achieved using only 150 mg/l $CaCl_2$. For these reasons, the summary of the phosphate removal results (Table 17) is divided into sections showing the removals with $CaCl_2$ alone, with addition of NaOH, and with alum and settling. The maximum phosphate removal, from 169 mg/l to

TABLE 14

SUMMARY OF CHANGES IN THE ORGANIC NITROGEN IN THE A.L.M.I. SYSTEM

INFLUENT					EFFLUENT					CHANGE				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	%	Date	%	%
8/6	10.1	8/7	5.6	7.8	8/7	13.8	8/8	7.5	11.25	8/8	-24	8/7	+146	+44

TABLE 15

SUMMARY OF THE INCREASE IN TOTAL DISSOLVED SOLIDS IN THE A.L.M.I. SYSTEM

INFLUENT					EFFLUENT					INCREASE				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	%	Date	%	%
8/19	690	8/15	390	442	8/21	1,100	8/15	400	713	8/21	144	8/15	2.5	61

FIGURE 16 – EFFECT OF $CaCl_2$ DOSAGE ON TOTAL DISSOLVED SOLIDS IN EFFLUENT FROM A.L.M.I. SYSTEM

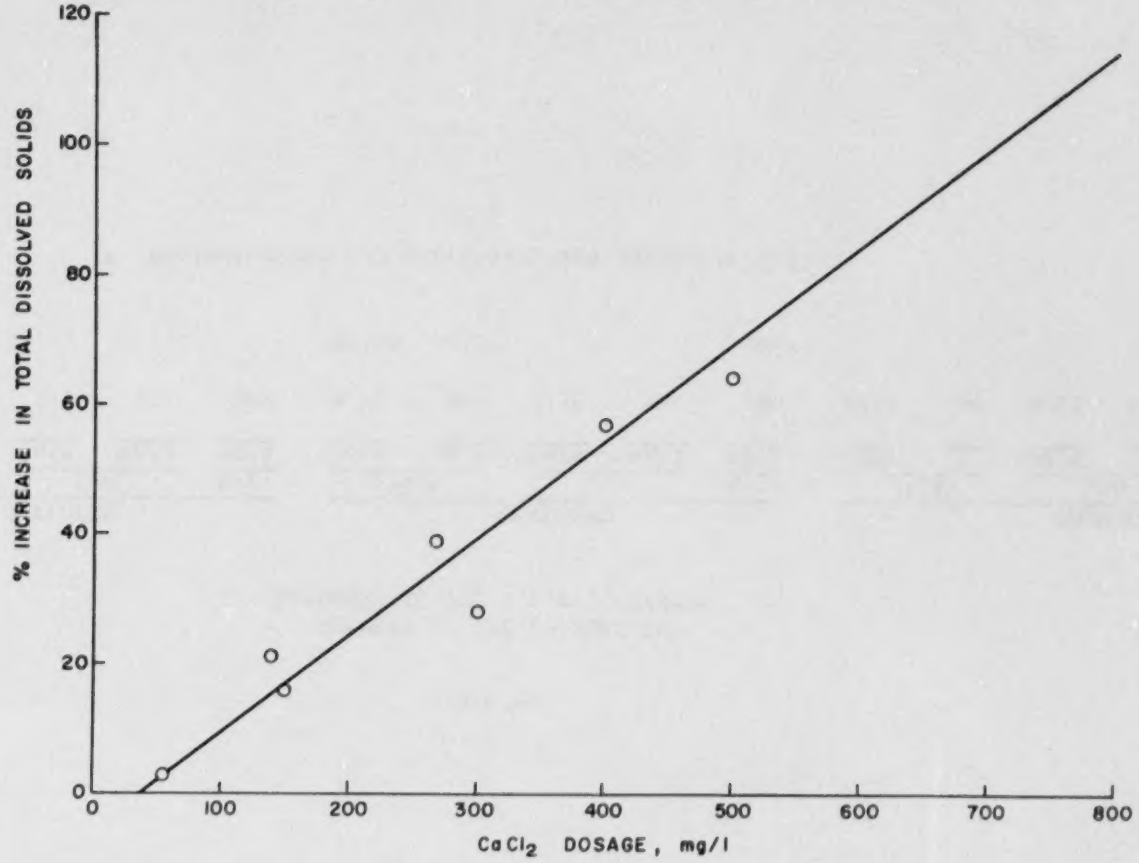


TABLE 16

SUMMARY OF THE CHANGES IN
HARDNESS IN THE A.L.M.I. SYSTEM

	INFLUENT					EFFLUENT					CHANGE				
	High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
	Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	%	Date	%	%
	8/19	248	9/3	172	209	8/21	668	8/19	96	284	8/19	-56	8/21	+660	+36
						8/19*	218*			166*					-20*

* Excluding two (2) extremely high values on 8/21

FIGURE 17 – EFFECT OF pH ON PO_4 REMOVAL IN THE A.L.M.I. SYSTEM

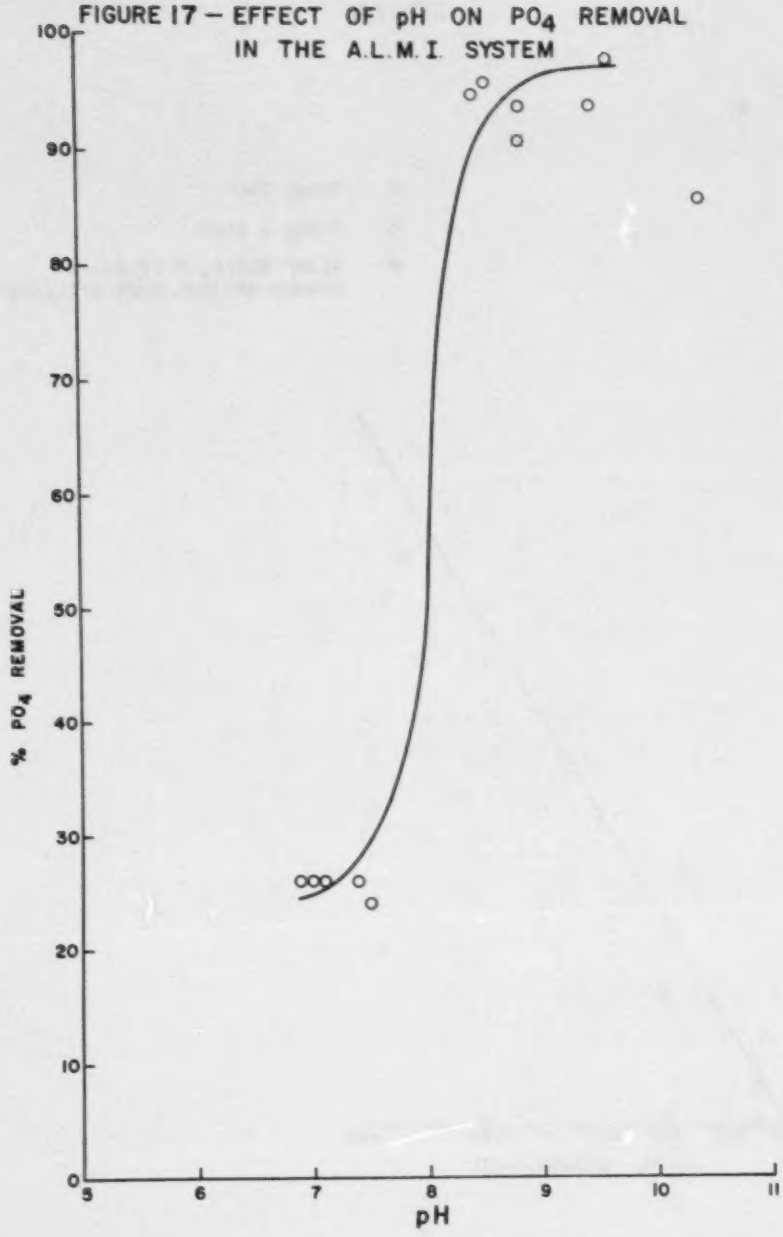


FIGURE 18 – EFFECT OF $CaCl_2$ DOSAGE ON PO_4 REMOVAL IN THE A.L.M.I. SYSTEM

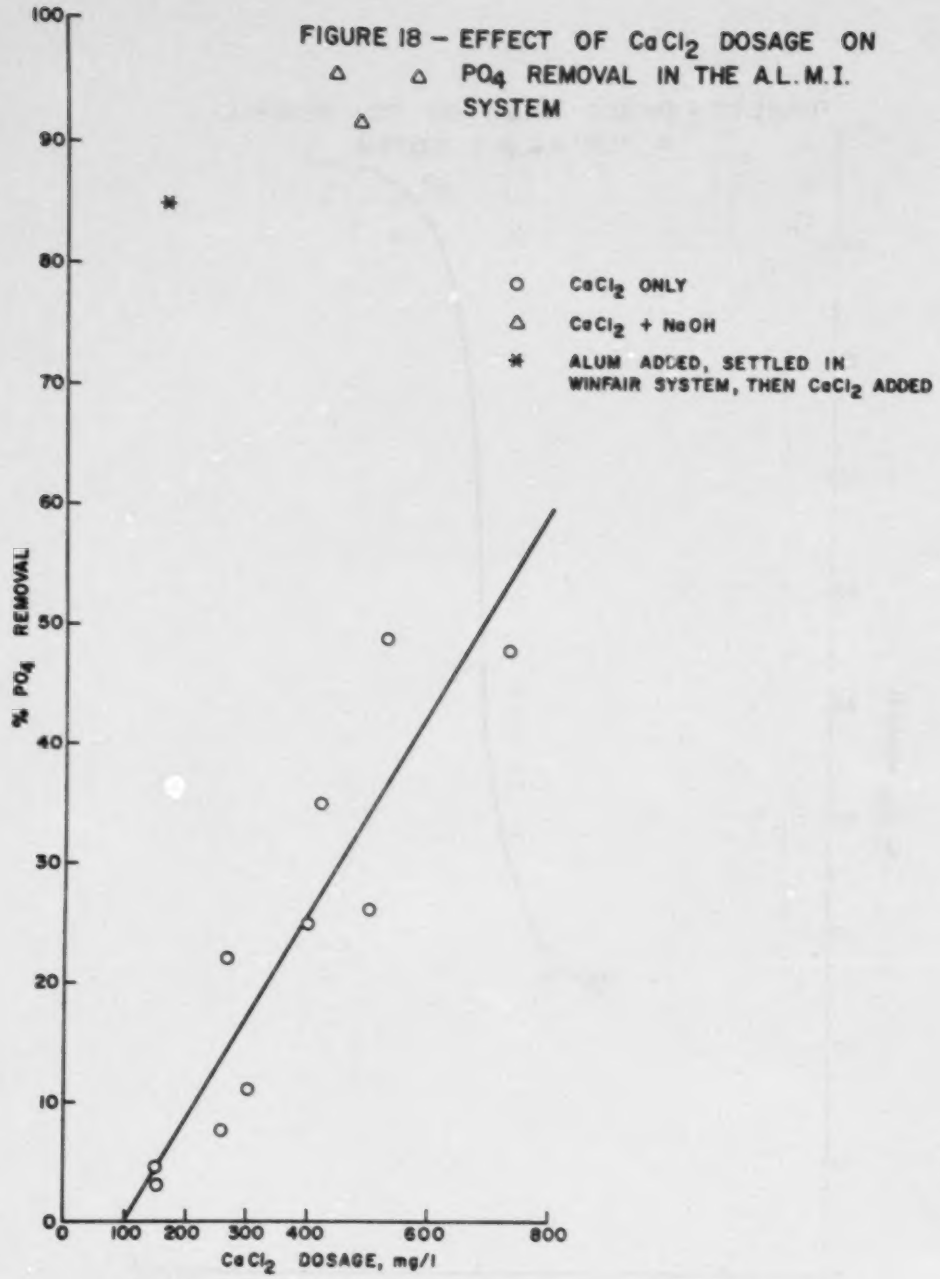


TABLE 17

SUMMARY OF PO_4 REMOVAL IN THE A.L.M.I. SYSTEM

INFLUENT						EFFLUENT						REDUCTION					
	High		Low		Avg.		High		Low		Avg.		High		Low		Avg.
	Date	mg/l	Date	mg/l	mg/l		Date	mg/l	Date	mg/l	mg/l		Date	%	Date	%	%
	9/11	199	8/12	84	146	$CaCl_2$ Only	9/11	199	8/21	55	113	$CaCl_2$ Only	8/21	50	9/11	0	22.6
															9/20	0	
						$CaCl_2$ + NaOH	8/28	28	8/29	3	11.7	$CaCl_2$ + NaOH	8/29	98	8/28	86	94
						Alum; Settled In Winfair; Then $CaCl_2$	9/22	36	9/22	9	24	Alum; Settled In Winfair; Then $CaCl_2$	9/22	95	9/22	80	87

3 mg/l, representing a 98% reduction, was obtained using Pitcher Celatom in a 50 lb. charge with the addition of NaOH to a pH of 9.55, and 435 mg/l of $CaCl_2$ with 18.3 mg/l of Roccal (23.77 to 1 ratio).

Alkalinity

The results of the alkalinity are summarized in Table 18. The average alkalinity in the raw waste was 368 mg/l with a range of 340 to 420 mg/l. With no addition of NaOH, there was an average slight reduction in alkalinity to 329 mg/l. With the addition of NaOH, the alkalinity increased to an average of 475 mg/l.

Acidity

The results of the acidity are summarized in Table 19. The average acidity in the raw waste was 91 with a range of 73 to 124 mg/l. With no NaOH added, the average acidity showed a slight increase to 112 mg/l during treatment. Upon addition of NaOH the acidity was lowered to an average value of 31 mg/l, with occasional instances of completely removing the acidity (pH > 8.3).

Optimum Operating Conditions

There was no one set of operating conditions which produced the maximum reduction of all parameters of pollution. However, the best overall results, as shown in Table 20, were produced under the following conditions: (1) 50 lbs. of Pitcher Celatom as filter aid; (2) a three minute pre-coat time; (3) 567 mg/l of $CaCl_2$; (4) 23.8 mg/l of active Roccal during a 7,530 gallon run; and (5) with the addition of NaOH. This combination of treatment resulted in: (1) 98% reduction of ABS from 21.6 mg/l to .20 mg/l, satisfactory for USPHS Drinking Water Standards; (2) a 73% reduction of BOD from 133 to 34 mg/l; (3) an 85% reduction of COD from 285 mg/l to 45 mg/l; (4) a 94% reduction of PO_4 from 169 mg/l to 6 mg/l; (5) a 97% transmittance for turbidity of the effluent; (6) no significant change in acidity; (7) raising the pH from an influent value of 7.2 to 8.5; (8) increasing the total dissolved solids (TDS) 44% from 488 mg/l to 715 mg/l; (9) little change in the alkalinity; (10) an 8% increase in the hardness from 208 mg/l to 266 mg/l; and (11) < 10 coliform/100 ml when chlorinating the effluent.

TABLE 18

SUMMARY OF THE ALKALINITY IN THE RAW AND TREATED WASTE

INFLUENT					EFFLUENT					EFFLUENT				
					NO NaOH ADDED					NaOH ADDED				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l
9/3	420	8/21	340	368	8/19	350	8/21	288	329	9/3	500	9/3	452	475

TABLE 19

SUMMARY OF THE ACIDITY IN THE RAW AND TREATED WASTE

INFLUENT					EFFLUENT					EFFLUENT				
					NO NaOH ADDED					NaOH ADDED				
High		Low		Avg.	High		Low		Avg.	High		Low		Avg.
Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l	Date	mg/l	Date	mg/l	mg/l
9/3	124	8/19	73	91	8/19	158	8/19	87	112	9/3	68	9/3	0	31

TABLE 20

OPTIMUM COMBINATION OF CHEMICAL AND MECHANICAL FACTORS IN REMOVAL OF POLLUTANTS AND PATHOGENS FROM LAUNDROMAT WASTE WATER IN THE A.L.M.I. WASTEWATER TREATMENT SYSTEM. FILTER AID-PITCHER CELATOM USING A 3 MINUTE PRE-COAT TIME-RESULTS BASED UPON 7530 GALLONS OF TREATED WASTE.

Filter Aid Dosage	$CaCl_2$ Dosage	Active Roccal Dosage	NaOH	ABS			BOD		
				Inf. mg/l	Eff. mg/l	Red'n. %	Inf. mg/l	Eff. mg/l	Red'n. %
50 lbs.	567 (mg/l)	23.8 (mg/l)	Yes	21.6	.20	98	133	34	73

COD			TDS			Turb.	PO_4			pH	
Inf. mg/l	Eff. mg/l	Red'n. %	Inf. mg/l	Eff. mg/l	Incr. %	% Trans. Eff.	Inf. mg/l	Eff. mg/l	Red'n. %	Inf.	Eff.
285	45	85	488	715	44	97	169	6	94	7.2	8.5

Acidity			Alkalinity			Hardness			Coliform/100 ml	
Inf. mg/l	Eff. mg/l	Red'n. %	Inf. mg/l	Eff. mg/l	Incr. %	Inf. mg/l	Eff. mg/l	Incr. %	Inf.	Eff.
91	89	2	368	372	1	208	266	8	> 2,000	< 10

SECTION XI

DISCUSSION OF THE ALMI SYSTEM

The first criterion for a satisfactory effluent is that it meet health department standards. In New York, this demands (1) an effluent which manifests a coliform count of zero after chlorination based upon a 1 ml sample and (2) a reduction of 75% in biological oxygen demand. The ALMI System meets the requirement with respect to the elimination of coliform organisms and at optimum conditions achieves a 73% reduction of BOD. The ABS and total solids in the effluent meet the U.S.P.H.S. drinking water standards.

The second requirement of a wastewater treatment system is the ability to handle peak loads as well as normal demands. The ALMI System proved able to treat a maximum of 25-26 gpm and also produce a satisfactory effluent at a regular flow of 14-15 gpm resulting in a total daily flow of 6300-8500 gallons per day. At two runs per day this unit can treat a total of 7530 gallons per day. At a maximum average flow of 587 gpd per washing machine as shown in Fig. 1, the maximum average daily effluent from 12-13 machines could be treated in these two runs. It required 252 minutes or 4.2 hours to treat the average daily effluent from approximately seven machines. Based upon a 12 hour day, the ALMI system could treat the average daily flow from approximately 20 machines. The holding tank of 4000 gallon capacity provided storage during peak flows.

The third requirement is that it requires a minimum of service, operational and maintenance skills and operator time. After the optimum combination of chemical and mechanical aids was determined, it required very little time to add the DE charge and refill the chemical solution reservoirs. However, with two runs a day, the operator would have to return to add the second DE charge. All the other operations were such that the system could be activated automatically by a float valve in the holding tank. It would be possible to install an automatic DE charging setup so that the system could operate unattended during the weekend which is usually the peak usage period of the laundromat. Also the sludge holding tank must be pumped out periodically, approximately on a weekly basis. This is best handled by a conventional septic tank service.

The fourth criterion is easily met be the ALMI system which was dismantled and removed to the R.P.I. laboratories with a minimum use of labor and transport facilities. It should be noted, however, that removal of the 4,000 holding tank, 1,000 gal. clean water tank and 1,000 gal. sludge tank was not included, as these are fairly permanently installed in the ground.

As for the space requirement, the fifth criterion, the ALMI system, exclusive of holding and storage tanks, required no more than 80 square feet, including storage of filter aids and chemicals, with a normal ceiling height.

An estimate was made for the cost of operation of the system. This was broken down as follows:

		cost/8,500 gal. day
Chemicals	$1.00/1,000 gal.	$ 8.50
Electric power	1.5 KW/hr., 9 hr./day @ 3¢/KW	.50
Labor, maintenance	1 hr./day @ $2.25/hr.	2.25
Sludge scavenging	$20/wk.	3.00
Misc.		.75
Total		$15.00

Based upon 30 gallons per wash, there are approximately $\frac{8,500}{30}$ = 280 washes per day. At $15.00 per day, this results in $\frac{1500}{280}$ = 6¢/wash. This value is slightly high, and would require the addition of at least 5¢ to the cost of each wash. This value does not include amortization of the cost of the treatment equipment. This would probably increase the total cost for treatment to 10¢ per wash. This is a significant increase in the cost. Thus, this system does not meet the requirements for an economical system.

The goal of recycling water for further use should be an ultimate aim of any waste water treatment system. In terms of reduction of spent detergents, phosphates, coliform organisms, turbidity, organic nitrogen, BOD and COD, the effluent could be reused for uses other than drinking. However, the increases in TDS, and pH, while within the upper limits of U.S.P.H.S. drinking water standards, might not be suitable for certain agricultural and industrial uses. Furthermore, the increase in alkalinity and hardness, due to the addition of NaOH, and the high ratio of $CaCl_2$ to Roccal (22.3:1) in order to increase PO_4 removal, render very questionable the suitability of the effluent for reuse without softening and pH adjustment.

The American Laundry Machinery Industries Diatomaceous Earth Filtration System can thus be an effective system for the treatment of laundromat wastes. Whereas there was no single optimum operating condition under which all waste parameters were removed to the greatest extent, there can be reached an optimum chemical addition and operation which will effectively treat the waste and render it safe for certain reuse or discharge into a receiving water.

SECTION XII

ACKNOWLEDGEMENTS

The laboratory studies in this project were supported by the New York State Department of Health, Division of Laboratories and Research.

The authors would like to thank Mr. James A. Messina for allowing the use of his laundromat treatment equipment for this project, Mr. Ralph Carpenter for providing the building to house and the power to operate the equipment, and Mr. Edwin Lagasse for cooperating in providing the laundromat waste. Diatomaceous Earth for this study was provided by the Johns-Manville Corp., Celite Division.

The operational studies were supported by a grant from the Federal Water Pollution Control Administration (now Federal Water Quality Administration), Department of the Interior. Special thanks is also extended to Mr. Richard Keppler, Project Officer, for his guidance.

SECTION XIII

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SECTION XIV

GLOSSARY

ABS - Alkyl benzene sulfonate; a constituent of detergents; in this paper used to connote both the older branched-chain non-biodegradable forms and the newer LAS.

Anion - An electronegative ion.

Cation - An electropositive ion.

Cercaria - The larval form of a parasitic worm.

Coliforms - A group of bacteria, native to the human intestinal tract, used as a water pollution index. The concentration of coliform bacteria is indicative of the extent of fecal contamination to the water.

Cysts - A capsule surrounding a microorganism in its resting state; it is shed after the organism resumes activity.

Diatomaceous earth - A fine earth derived from the cell walls of diatoms and used as an absorbent.

LAS - Linear alkyl benzene sulfonate; now a constituent of the new biodegradable detergents.

Roccal - The commercial name for a quaternary ammonium compound which is both a cationic detergent to remove residual anionic detergents and a germicide to kill bacteria.

Schistosome - A genus of worm, parasitic in the blood of man.

Syndets - Synthetic detergents.

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*U.S. GOVERNMENT PRINTING OFFICE: 1973 514-153/200 1-3